Agriculture to Industry: the End of Intergenerational Coresidence*

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Abstract

We show that the structural change of the economy from agriculture to industry was a major determinant of the observed shift in intergenerational coresidence. We build a one-good, two-sector overlapping generation model of the structural change out of agriculture, in which the coresidence choice is endogenous. We calibrate the model on U.S. data and simulate it. The model can match the decline in U.S. intergenerational coresidence both qualitatively and quantitatively.

Keywords: living arrangements, family economics, structural change, economic development, unified growth theory

JEL Classification: J10, O40, O11, O33, E13

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1 Introduction

In this paper, we provide a macroeconomic model in which the structural change out of agriculture determines a shift from intergenerational coresidence to the nuclear family, and we quantify the importance of this mechanism by means of numerical simulations for the United States between the 19th and 20th century.

The family structure in the United States has changed significantly since the nineteenth century. One of the major changes has been the shift from intergenerational coresidence to independent living arrangements for the elderly: according to data, the percentage of elderly persons residing with their adult children plummeted from 69% in 1850, to almost 17% in 1990 (see Figure 1).[1]

Figure 1 also shows that a companion fact to the change in intergenerational coresidence was the structural change out of agriculture. If we compare the intergenerational coresidence rate with the employment rate in agriculture between 1850 and 2010, we observe that the two time series show similar behaviour, suggesting the existence of a link between the two phenomena. In Section 2, we delve more deeply into this empirical evidence, and show that there actually exists a robust correlation between employment in agriculture and intergenerational coresidence.[2]

To rationalise the evidence, we propose a formal model based on technical change and the relative income of the different generations. Higher technical change in the industrial sector with respect to the agricultural sector causes a progressive reallocation of labour from agriculture to industry and affects the relative income of the different generations. This in turn changes the decision power of the different generations, and therefore the incentive to coreside.

More specifically, we build a one-good, two-sector overlapping generation model with agriculture and industry à la Hansen and Prescott (2002). We assume that the old own all the land, and receive a rent from it, while the young provide the labour force. The young can work in both the agricul-

[1] A survey by the United Nations confirms that there is a global trend, across countries and over time towards more independent living arrangements among the elderly. See United Nations (2005).

[2] The existence of a possible link between intergenerational coresidence and the shift from agriculture to industry is accepted by many sociologists and demographers. For instance, Ruggles (2007) argues that the shift from agriculture to industry allowed the younger generations to earn their way out of the family life: as a matter of facts, the emergence of wage labour during the process of industrialization made them independent, as they were not forced to work on the property of the family anymore, typically land or handicraft shops.

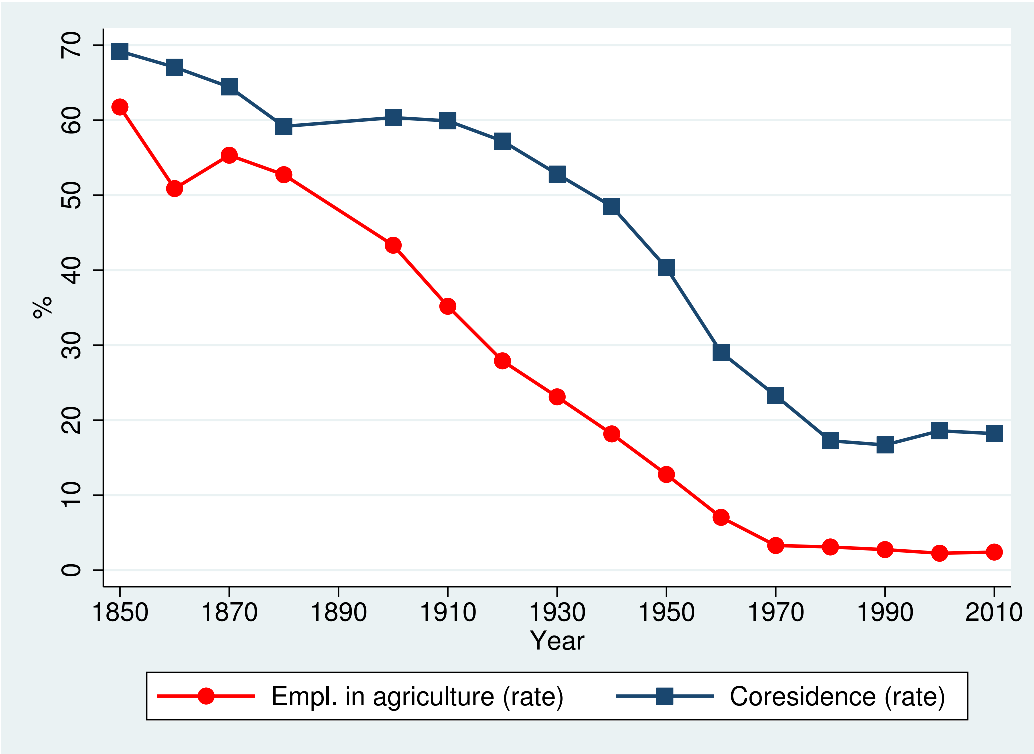

Figure 1: Intergenerational coresidence rate and employment rate in agriculture in the United States, 1850-2010. Intergenerational coresidence rate: at the numerator, the number of intergenerational households, i.e. the number of households in which one person aged more than 65 is living with at least one child aged between 18 and 64; at the denominator, the number of households with at least an elderly member, i.e. aged more than 65. Source: our elaboration on Ruggles et al. (2017). Persons living in group quarters such as rooming houses and military barracks are excluded from the sample. Employment rate in agriculture: percentage of individuals employed in agriculture over the total labour force. Source: our elaboration on Ruggles et al. (2017). We use the reconstructed IPUMS data on occupation available as the variable *IND1950*. For both series, census data in 1890 are missing. Alaska, District of Columbia and Hawaii are excluded from the sample.

tural and the industrial sector, their choice being driven by a no-arbitrage condition on wages in the two sectors. We model the endogenous choice of coresidence as in Pensieroso and Sommacal (2014). In that framework, coresidence is deeply influenced by the relative income of the young with respect to the old. In particular, coresidence decreases when the relative income of the young increases. As productivity in the industrial sector relative to productivity in the agricultural sector takes off, employment shifts from agriculture to industry. The functional distribution of income changes: the wage earned by the young increases, while the rent earned by the old decreases. Therefore, the industrial take off implies a lower coresidence rate.

We calibrate the model to U.S. data and simulate it to quantify the relevance of the proposed mechanism. Our model can reproduce the qualitative behaviour of the intergenerational coresidence rate for the whole period. Furthermore, the model matches the decline in intergenerational coresidence well from a quantitative point of view: it accounts for 71% of the overall observed drop between 1870 and 2010.

This article is linked to three strands of the literature: the literature on the structural change out of agriculture, the literature on intergenerational coresidence and the literature on family patterns and economic growth.

The structural change out of agriculture, whose explanation is still debated, is a defining feature of the industrial revolution. Its role in determining economic development is hardly controversial, as witnessed by a long standing literature in economic development.[3]

For what concerns the decline in intergenerational coresidence, different theories have been advanced in the literature to explain it. A group of authors maintain that the introduction of Social Security is the engine behind the observed shift in the coresidence pattern.[4] According to this perspective, also known as the "affluence hypothesis", intergenerational coresidence was imposed on the elderly by the lack of alternatives. Others take the opposite view, also known as the "economic development hypothesis", and attribute the shift to the increased income of the young.[5] The two perspectives can actually be viewed as complementary rather than alternative, and the pre-eminence of one over the other possibly depends

[3]See for instance Alvarez-Cuadrado and Poschke (2011) Doepke (2004), Gollin et al. (2002), Hansen and Prescott (2002), Harris and Todaro (1970), Herrendorf et al. (2013), Kuznets (1966), Lewis (1954), Nurkse (1953), Rostow (1960).

[4]See for instance Bethencourt and Rios-Rull (2009), Costa (1997), McGarry and Schoeni (2000), among others.

[5]Aquilino (1990), Pensieroso and Sommacal (2014), Ruggles (2007), Ward et al. (1992), Whittington and Peters (1996), to mention but a few.

on the period under exam. In particular, since the Social Security Act dates to 1935, the economic development hypothesis seems more relevant for the period before WWII, when there was virtually no Social Security; while the affluence hypothesis might be of some importance for the period after 1950, when Social Security payments became widespread in the United States. As our story focuses on the link between the structural change out of agriculture during the industrial take-off and intergenerational coresidence, much of the action takes place before 1950. In facts, the employment rate in agriculture was already down to 13% in 1950, from 62% in 1850; while the coresidence rate dropped from 69% in 1850 to 40% in 1950 (see Figure 1).[6] Accordingly, drawing inspiration from Pensieroso and Sommacal (2014), we build a quantitative macroeconomic model of the economic development hypothesis to assess how much of the observed decline in intergenerational coresidence can be explained by the structural change out of agriculture, abstracting from other possible explanations like Social Security and cultural change.

Finally, this article contributes to the literature exploring the link between family patterns and economic growth.[7] With respect to this literature, we are the first to introduce a quantitative macroeconomic model to study how the structural change out of agriculture during the industrial revolution might have affected intergenerational coresidence.[8]

The rest of the paper is organised as follows. Section 2 discusses the definition of intergenerational coresidence, the empirical link between employment in agriculture and intergenerational coresidence and the relevance of our proposed mechanism with respect to possible competing

[6]Notice that the emergence of Social Security has been often described in the socio-demographic literature as the policy answer to a pre-existing progressive deterioration of the economic conditions of the elderly, due to the structural change out of agriculture and the ensuing change in family living arrangements (see for instance Ruggles (2007)). A similar argument was maintained by Caucutt et al. (2012). Using a political economics model, they show that the structural change out of agriculture created the conditions necessary for the approval of Social Security, because land had progressively been losing importance as asset to finance old-age consumption. Consequently, the need of intergenerational transfers emerged, and social security could be supported by the median voter.

[7]Baudin and Stelter (2016), Blackburn and Cipriani (2005), de la Croix and Vander Donckt (2010), Doepke and Tertilt (2016), Doepke and Tertilt (2014), Edlund and Lagerlöf (2006), Greenwood et al. (2017), Iyigun and Walsh (2007), Mariani (2012).

[8]Salcedo et al. (2012) propose a quantitative model of the secular change in the household size as well. However, in their framework families are collections of room-mates and accordingly the focus is not on intergenerational issues. Moreover the key mechanisms of their paper hinges on non-homothetic preferences and is not related to the structural change out of agriculture.

explanations. Section 3 presents the model. In Section 4 we calibrate the model to U.S. data and simulate it. Section 5 concludes.

2 Empirical evidence

In this article, we maintain that the structural change out of agriculture has been a major determinant of the end of intergenerational coresidence, and we provide a theoretical mechanism for it.

Before describing the model, in this Section, we discuss the empirical evidence sustaining our hypothesis. First, in Section 2.1, we discuss the whereabouts of our definition of intergenerational coresidence, showing that the measure presented in Figure 1 accurately reflects changes in the willingness to form an intergenerational household.

Second, in Section 2.2, we show that there exists a robust empirical correlation between the employment rate in agriculture and the intergenerational coresidence rate.

Finally, in Section 2.3, we discuss possible competing stories, focusing in particular on demographic and geographical factors as drivers of the decrease in intergenerational coresidence. We show that our theoretical mechanism based on the employment rate in agriculture is still relevant and important compared to these alternative stories.

2.1 Measurement issues

A first thing worth discussing is the way in which we measure intergenerational coresidence, i.e. the relevance of intergenerational households in the society. Intergenerational households are those in which an elderly person is living with at least one adult child. In our benchmark definition, the one used in Figure 1, the intergenerational coresidence rate, π, is the number of intergenerational households divided by the total number of households in which there is at least one elderly person.

Alternative definitions are possible. In particular, one could define the intergenerational coresidence rate symmetrically as the number of intergenerational households divided by the total number of households in which there is at least one young person. Let us call this alternative measure π^y. In Table 1, Columns (1) and (2), we report the values of π and π^y in the United States for four decades between 1850 and 2000. We observe that while our benchmark definition depicts a clear decreasing trend for intergenerational coresidence, the alternative definition does not. These

	(1)	(2)	(3)
	π	π^y	π^p
1850	69.17	8.18	11.82
1900	60.34	9.49	15.73
1950	40.31	8.98	22.27
2000	18.57	5.27	28.36

Table 1: Coresidence rate: alternative measures (percentage rate). Source: our elaboration on Ruggles et al. (2017). Column (1), our benchmark definition (see Figure (1) for sources and further details): at the numerator, the number of intergenerational households, i.e. the number of households in which one person aged more than 65 is living with at least one child aged between 18 and 64; at the denominator, the number of households with at least an elderly member, i.e. aged more than 65. Column (2): at the numerator, the number of intergenerational households; at the denominator, the total number of households with at least one young agent, i.e. agents aged between 18 and 64. Column (3): at the numerator, the number of households with at least an elderly member; at the denominator, the total number of households with at least one young agent, i.e. agents aged between 18 and 64.

differences in both trend and level raise a general question, namely what is the criterion that makes one definition preferable to the other.

In order to clinch the matter, consider that the same level of coresidence might have a different meaning in different contexts. For instance, low coresidence when there are few possibilities of forming an intergenerational family (e.g. because life expectancy is low, so parents die relatively young) is a different phenomenon than low coresidence when there are plenty of possibilities of forming an intergenerational family (e.g. because life expectancy is high, so parents live longer). Intuitively, since the potential for coresidence has changed, the willingness to coreside must be different in the two cases. We would like to have a measure of intergenerational coresidence that takes that intuitive difference into account. A way of doing so is to build a coresidence rate that represents the fraction of potential coresidence that is actually realized.[9] As we argue below, our measure of intergenerational coresidence π can be exactly interpreted in this way, while π^y cannot.

To grasp the point, consider the following example. Suppose that in period t the economy is populated by one hundred young agents and one old. Assume there is only one intergenerational household, formed by one

[9]See Ruggles (1996).

young and one old, and ninety-nine non-intergenerational households, each formed by one young agent. In such a scenario, all the possibilities to form intergenerational households have been exploited: indeed, the maximum number of intergenerational households that could be formed is exactly equal to one, since there is only one old. If we measure π and π^y in this economy, we obtain $\pi_t = 1/1 = 100\%$ and $\pi_t^y = 1/100 = 1\%$. Now suppose that in period $t + 1$ the number of old increases to fifty. Assume there is still only one intergenerational household, formed by one young and one old. Contrary to what observed in period t, actual coresidence is no longer equal to potential coresidence: the maximum number of intergenerational household is now equal to fifty, while there is only one actual intergenerational household. Intuitively, the willingness to coreside has changed: while in period t all the possibilities to form intergenerational households have been exploited, in period $t + 1$ only some have. Our claim is that, in such a situation, a good measure of intergenerational coresidence should register a variation between t and $t + 1$. Measuring π and π^y in this economy, we obtain $\pi_{t+1} = 1/50 = 2\%$ and $\pi_{t+1}^y = 1/100 = 1\%$. So, it appears that our benchmark definition π reflects changes in the willingness to coreside, while π^y does not. The rational for this is that, in this example the potential for coresidence has changed over time, because the number of old has changed over time. Our definition takes that into account, for the coresidence rate is defined relative to the number of old agents, which in turn determines the potential for coresidence. In other words, the intergenerational coresidence rate π can be interpreted as the percentage of potential coresidence that is actually realised, i.e. 1 over 1 in period t and 1 over 50 in period t+1. On the contrary, π^y does not take the evolution of potential coresidence into account because is defined relative to the number of young agents.[10]

We are now going to generalize the example. Call $H^{y,o}$ the number of intergenerational households, i.e. those formed by at least one old and at least one young, H^y and H^o the number of non-intergenerational households, i.e. those made by the young only and the old only, respectively.

[10]Notice that in our example potential coresidence depends on the number of the old, since we are assuming that there are more young than old agents. Had we assumed that there are more old than young agents, potential coresidence would have depended on the number of the young, and π^y would have captured changes in the willingness to coreside. In other words, it is always the "short side" of the market, so to speak, to determine the extent of potential coresidence. Since in the period under exam individuals aged more than 65 have always constituted a small portion of the population, the number of old persons is the crucial determinant of potential coresidence.

With this notation, the definitions for π and π^y can be written as:

$$\pi \equiv \frac{H^{y,o}}{H^{y,o} + H^o}. \tag{1}$$

$$\pi^y \equiv \frac{H^{y,o}}{H^{y,o} + H^y}. \tag{2}$$

Notice that the denominator of π corresponds to the maximum number of possible intergenerational households, that is the number of actual intergenerational households plus the maximum number of new intergenerational households that can be formed.[11] It follows that π can logically be interpreted as the fraction of the potential coresidence actually realised. Therefore, like in our example, π measures the willingness to coreside. On the contrary, π^y does not, since the denominator in Equation (2) does not catch the evolution of potential coresidence.

To better understand the relationship between π and π^y, it's useful to rewrite π in the following way:

$$\pi = \frac{\pi^y}{\pi^p}, \tag{3}$$

where

$$\pi^p \equiv \frac{H^{y,o} + H^o}{H^{y,o} + H^y}. \tag{4}$$

The variable π^p has a straightforward interpretation: it is the potential coresidence rate, corresponding to the actual coresidence rate π^y. In fact, the numerator in π^p is the maximum number of intergenerational households, while the denominator is the same as π^y, i.e. the number of households with at least one young member. Equation (3) makes clear that our benchmark coresidence rate π can be interpreted as a "corrected" coresidence rate, i.e. a measure of coresidence corrected by the evolution of the potential rate.[12]

[11]This in turn depends upon the minimum between the number of non-intergenerational households made by young persons only and the number of non-intergenerational households made by old persons only. So, the general formula for the denominator of Equation (1) should be $H^{y,o} + \min(H^y, H^o)$. However, in our data $\min(H^y, H^o)$ is always equal to H^o. Notice that our reasoning makes the simplifying assumption that each old agent has a surviving child.

[12]It turns out on reflection that this is not specific to the definition of π^y. For instance, suppose we define the intergenerational coresidence rate as the percentage of intergenerational households over total household:

$$\pi^{tot} \equiv \frac{H^{y,o}}{H^{y,o} + H^o + H^y}.$$

It turns out that π^p depends on the demographic structure of the population, that is on the relative number of old agents. In particular, it is possible to argue that an increase in the relative number of old agents must increase π^p.[13]

In Table 1 (Column 3), we report the measured values of π^p for the period 1850-2000. We observe that π^p is markedly increasing over time,

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The argument we have developed so far for π^y applies, *mutatis mutandis*, also to π^{tot}. We could identify a potential coresidence rate, which is the maximum potential intergenerational coresidence over the population of reference, total household in this case:

$$\pi^{p,tot} \equiv \frac{H^{y,o} + H^o}{H^{y,o} + H^o + H^y}$$

Accordingly, the ratio between π^{tot} and $\pi^{p,tot}$ would give us the corrected coresidence rate, i.e. the fraction of potential coresidence that is realized:

$$\frac{\pi^{tot}}{\pi^{p,tot}} = \frac{H^{y,o}}{H^{y,o} + H^o} \equiv \pi.$$

Results in Table 1 hold unchanged if we use π^{tot} and $\pi^{p,tot}$ instead of p^y and p^p. Details available upon request.

[13]To understand the relationship between π^p and the demographic structure of the population, rewrite π^p as:

$$\pi^p = \frac{\frac{H^{y,o}+H^o}{N^o}}{\frac{H^{y,o}+H^y}{N^y}} \frac{N^o}{N^y} = \frac{\frac{N^o}{m^o}}{\frac{N^y}{m^y}},$$

where N^o is the number of the old in the population, N^y is the number of the young in the population, $m^o \equiv N^o / (H^{y,o} + H^o)$ is the mean number of old who live in a household with at least one elderly member and $m^y \equiv N^y / (H^{y,o} + H^y)$ is the mean number of young who live in a household with at least one young member. This formulation allows to infer that changes in N^j, with $j = y, o$, will translate in changes in π^p only if they are not absorbed by variation in m^j. The idea is that variations in N^j can translate into variations of the number of households with at least one individuals j and/or in variations of the average number of individuals of type j within each household. In the extreme case, if the number of households with at least one individuals j changes one to one with N^j, then m^j is constant, and any changes in N^j translates into π^p. Suppose that the number of the old increases, for instance because of an increase in life expectancy. If this translates into an increase of the number of households with at least one elderly member, then π^p will increase. If instead the number of households with at least one elderly member remains constant, then m^o increases and π^p remains constant. It seems reasonable to assume that an increase in the number of old will not be entirely absorbed by an increase in m^o. Accordingly, we expect that π^p should increase as well. For what concerns an increase in the number of young, due for instance to an increase in the fertility rate, we know that in the period under exam, the prevalent intergenerational family model in the United States was the stem-family, in which elderly parents live with maximum one adult child (see Ruggles (2003)). Accordingly, increases in the number of young agents will mostly translate into increases of the number of households with at least one young member, and therefore a decrease of π^p. This suggests that π^p is increasing in N^o/N^y.

possibly due to the actual increase in life expectancy and decrease in fertility. This observation, coupled with the near-constancy of π^y, implies that willingness to form an intergenerational household as measured by π is declining, as made clear by equation (3).

We can thus conclude that the measured decrease in π single out a decline in the willingness to live in intergenerational households. This is the stylised fact we want to explain in this article.[14]

Independent variable: Coresidence rate			
	(1)	(2)	(3)
Employment in agriculture	0.591***	0.717***	0.768***
	(0.0206)	(0.0188)	(0.0359)
Constant	25.39***	15.46***	
	(0.770)	(2.702)	
State fixed effects	no	yes	yes
IV	no	no	2^{nd} stage
Observations	732	732	693
R-squared	0.529	0.704	0.683
Number of states	48	48	48
*** p<0.01, ** p<0.05, * p<0.1			

Table 2: Regression results. Independent variable: intergenerational coresidence rate. Robust standard errors in parentheses (clustered at the state level when using fixed effects). Instrumental variable in the IV regression: 1-period-lagged employment in agriculture.

2.2 The role of employment in agriculture

We come now to the bulk of our argument, namely the empirical correlation between employment in agriculture and intergenerational coresidence.[15]

[14]For robustness, we have also computed our benchmark definition of the intergenerational coresidence rate for different demographic subgroups. First, we have discriminated along the marital status of the old, to check in particular whether results are driven by widows. Second, we have used different definitions of who is old and who is young in the data, to check whether the behaviour of young unmarried children is driving the pattern of coresidence. In both cases, the drop in intergenerational coresidence is similar to the one obtained using our benchmark definition. Results available upon request.

[15]According to the theory we develop in section 3, the structural change out of agriculture affected intergenerational coresidence via changes in the functional distribution of income that induced variations in the relative income of the young with respect to the old. Hence, a more direct test of our theory would be to study the correlation between the intergenerational coresidence rate on the one hand, and the relative income (or the functional distribution of income) on the other hand. However, to the best of our knowledge: a) state-level data on the relative income of the young are only available after 1950 in IPUMS;

We build intergenerational coresidence rates and employment rates in agriculture for each State of the United States between 1850 and 2010 (excluding Alaska, Hawaii and Washington DC).[16] So we have a panel with 48 observations for 16 decades (census data for 1890 are missing).

Table 2 shows results from our regression analysis. In column (1) we regress the intergenerational coresidence rate on the employment rate in agriculture. It turns out that the correlation is positive and significant at the 1% level. An increase in the employment rate in agriculture by 1 percentage point increases the intergenerational coresidence rate by almost 0.6 percentage points. In column (2), we control for state-fixed effects. The coefficient on the employment rate in agriculture is still positive and significant at the 1% level. Moreover, its quantitative importance increases: once time-invariant differences across States are taken into account, an increase in the employment rate in agriculture by 1 percentage point increases the intergenerational coresidence rate by 0.7 percentage points.

Independent variable: Employment in agriculture (t)	(1)
Employment in agriculture (t-1)	0.909***
	(0.0123)
Observations	693
Number of clusters	48
F(1,47)	5496.9
*** p<0.01, ** p<0.05, * p<0.1	

Table 3: First stage IV regression. Independent variable: employment rate in agriculture at time (t). Robust standard errors clustered at the state level in parentheses.

Although we are mostly interested in correlations here, the panel dimension of our data allows us to go one step further towards investigating a causal link. One *caveat* in interpreting the above correlations in terms of

b) state-level data on the functional distribution of income are only available from 1939 (see Carson (1975)). This data limitation is stringent because the period before WWII is of particular interest for our analysis. Indeed, in that period a large drop in the coresidence rate took place. Furthermore, for that period the economic development hypothesis, on which our theory is based, is more compelling, since social security became sizeable only after 1950. Hence, in order to include the period before WWII, the econometric analysis we perform focuses on the relationship between the intergenerational coresidence rate and the employment rate in agriculture, a measure of the structural change for which data are available since 1850.

[16]For definitions and computation methods see the caption of Figure 1.

causality is that there might be a reverse-causality problem: intergenerational coresidence might have determined the employment rate in agriculture and not the other way round. The idea is that it is more likely that the young was working on the family estate (land), in case of intergenerational coresidence.

To deal with this problem, we instrument the employment rate in agriculture on its one-period lagged value, and run an IV regression. The exclusion restriction is that the lagged employment rate in agriculture has no direct effect on the current coresidence rate other than the effect it holds on the current employment rate in agriculture. Results from the first stage of the IV regression are shown in Table 3 and suggest that the lagged employment rate in agriculture is a good instrument. Results for the second stage of the IV regression are shown in Table 2, column (3). The coefficient on the employment rate in agriculture is still positive and significant at the 1% level. Quantitatively, an increase in the employment rate in agriculture by 1 percentage point increases the intergenerational coresidence rate by 0.77 percentage points.

This evidence suggests that the employment rate in agriculture could have affected the intergenerational coresidence rate. In this article, we provide a theoretical mechanism that rationalises this evidence, and quantify its the relevance via numerical simulations.

2.3 Competing explanations

Before presenting the model, we discuss the relevance of possible competing explanations here below. We focus in particular on demography (fertility and longevity) and the process of urbanization.

2.3.1 Demography

The idea that fertility could have reduced intergenerational coresidence is somewhat intuitive: intergenerational coresidence seems a more likely outcome for a parent of five children than for a parent of one. For the first parent, the "chance" to find a child to coreside with, so to speak, should be higher than for the second.[17]

To understand whether changes in fertility have had an impact on the evolution of the intergenerational coresidence rate π, we enrich the analysis

[17] Although this argument looks self-evident, it actually hides behavioural assumptions. In particular it assumes implicitly that the probability to coreside with each child is independent on the number of children, which is not obvious.

of Section 2.2 by adding fertility as a control in the IV regression of Table 2. The measure of fertility we consider is 'children ever born', for women aged more than 64, a variable available from the U.S. Census data for the period 1900-1990 (with missing data for 1920-1930).

Independent variable: Coresidence rate	(1)	(2)	(3)
Employment in agriculture	0.768***	0.416***	0.409***
	(0.0359)	(0.0875)	(0.0903)
Fertility		7.478***	6.317***
		(1.188)	(1.1251)
Demographic structure			0.395**
			(0.1812)
State fixed effects	yes	yes	yes
IV	2^{nd} stage	2^{nd} stage	2^{nd} stage
Observations	693	377	377
R-squared	0.683	0.811	0.815
Number of states	48	48	48
*** p<0.01, ** p<0.05, * p<0.1			

Table 4: Regression results. Independent variable: intergenerational coresidence rate. Robust standard errors in parentheses (clustered at the state level when using fixed effects). Instrumental variable in the IV regression: 1-period-lagged employment in agriculture.

Independent variable: Employment in agriculture (t)	(1)	(2)	(3)
Employment in agriculture (t-1)	0.909***	0.785***	0.775***
	(0.0123)	(0.0561)	(0.0562)
Fertility		1.521	-0.488
		(0.9888)	(0.7992)
Demographic structure			0.678***
			(0.2096)
Observations	693	377	377
Number of clusters	48	48	48
F(1,47)	5496.9	196.1	194.2
*** p<0.01, ** p<0.05, * p<0.1			

Table 5: First stage IV regression. Independent variable: employment rate in agriculture at time (t). Robust standard errors clustered at the state level in parentheses.

We report the results in Table 4.[18] Column (1) is the same as Column (3) in Table 2 and is reproduced here for comparison. Column (2) reports

[18]Column (2) in Table 5 reports results from the first-stage regression. They suggest that the lagged employment rate in agriculture is a good instrument.

the results of the IV regression in which we add fertility as a covariate: the coefficient of employment in agriculture is still important and highly significant, once we control for fertility.

Beyond fertility, another demographic variable that could have influenced π is longevity. Unfortunately, to the best of our knowledge, state-level data on longevity are only available after 1960,[19] when the largest drop in π has already taken place. Accordingly, for longevity we cannot perform exactly the same empirical analysis that we carried out for fertility. To understand whether changes in longevity have had an impact on the evolution of the intergenerational coresidence rate π, we enrich our analysis by adding another variable, that once considered together with fertility, can possibly proxy changes in longevity. This variable is the demographic structure of the population, i.e. the ratio between the number of young and old agents. To be consistent with our definition of intergenerational coresidence, we compute the demographic structure of the population as the ratio between the number of individuals aged 18 to 64 and the number of individuals aged more than 64, using Census data. Column (3) in Table 4 reports the results of the IV regression controlling for both fertility and the demographic structure of the population.[20] Results show that the coefficient of employment in agriculture is still important and highly significant, once we control for both fertility and the demographic structure of the population, which we consider as a proxy for longevity.[21]

While our analysis so far has shown that the fall in the employment rate in agriculture is strongly correlated with the fall in intergenerational coresidence, and that this correlation is robust to the inclusion of demographic variables, still the coefficients associated to fertility and the demographic structure of the population are important and significant as well.

To grasp the relative quantitative importance of the two explanations,

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[19] See the United States Mortality DataBase, University of California, Berkeley, available at `usa.mortality.org`.

[20] Column (3) in Table 5 reports results from the first-stage regression. They suggest that the lagged employment rate in agriculture is a good instrument.

[21] It should be noticed that both fertility and the demographic structure of the population are significant in Column (3) of Table 4. This result suggests that fertility has an impact on π that goes beyond the obvious impact it has on the demographic structure of the population. By the same token, longevity could have an impact on π that is not fully captured by the use, as a proxy, of the demographic structure of the population (jointly considered with fertility). However, notice that, for what concerns longevity, we know that in the United States the average life expectancy at 65 did not change significantly between 1900 (11.86 years) and 1941 (12.80 years) (see Arias et al. (2017)). After WWII, we observe instead a clear increasing trend, with life expectancy at 65 reaching 19.40 years in 2014. This suggests that longevity could not have played an important role before WWII.

employment in agriculture and demography, we have run the following exercise. We have predicted the decline in intergenerational coresidence between 1900 and 1990 by multiplying the decline in employment in agriculture by the regression coefficient in Table 4, Column (2). We have done the same prediction exercise for demography (fertility and the demographic structure). We have then computed the predicting power of the different explanations, by dividing the predicted over the actual decline in intergenerational coresidence. Results are reported in Table 6. It turns out that the measured fall in employment in agriculture (fertility+demographic structure) can account for 38% (45%) of the actual decline in intergenerational coresidence.[22] So, while demography might have been important (and might well deserve to be further explored for its own sake), the structural change out of agriculture has likely played a significant role in explaining the decline in intergenerational coresidence. This will be our focus in this article.

	(1)	(2)	(3)	(4)	(5)
	1900	1990	Regression coefficient	Predicted decline in coresidence	Predicted/actual decline in coresidence
Empl. agr.	43.3%	2.7%	0.409	16.6%	38.4%
Fertility	5.2	2.5	6.317	17.0%	39.3%
Demographic structure	9.7	3.2	0.395	2.6 %	5.9%

Table 6: Explaining the decline of the intergenerational coresidence rate in the United States, 1900-1990: the importance of employment in agriculture, fertility and the demographic structure. Source: our elaboration on Ruggles et al. (2017). Column (1)-(2): data. Column (3): coefficient from the IV regression (Column (3) in Table 4). Column (4): [Column (1)-Column (2)]× Column (3). Column (5): Column (4) divided by the actual decline in intergenerational coresidence between 1900 and 1990, i.e. 43%.

2.3.2 Location

Our theory maintains that the structural change out of agriculture was a major determinant of the decline in intergenerational coresidence in the United States. The theoretical mechanism hinges on modifications of the relative income of the young, due to changes in the functional distribution of income. However, our mechanism based on relative income is not the

[22] We have also run our regression analysis with the demographic structure but without fertility as a control. Results show that the employment rate in agriculture is still highly significant and quantitatively even more important. Results available upon request.

only possible channel through which the falling rate of employment in agriculture might have affected intergenerational coresidence. An obvious alternative channel is the choice of location. Indeed, the structural change out of agriculture was historically characterised by a sizeable shift of population from rural to urban areas. So, according to this story, urbanisation would lie behind the observed change in coresidence patterns. The empirical prediction one may draw from this alternative story is that the observed decline in intergenerational coresidence is mostly to be ascribed to a decline of coresidence in rural areas, as adult children would be leaving to work in the city. On the contrary, no obvious trend should emerge in urban areas.

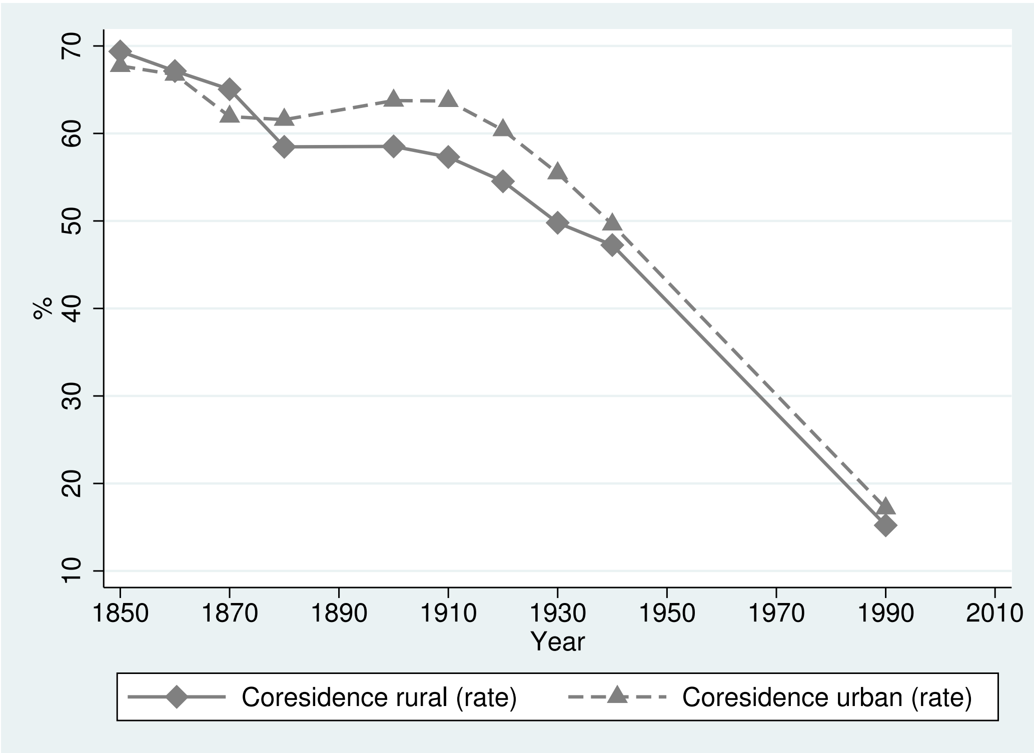

Figure 2: Intergenerational coresidence rate in the United States, 1850-2010: urban *versus* rural area. Source: Ruggles et al. (2017). The intergenerational coresidence rate is computed as explained in Figure (1). We use the IPUMS variable *URBAN* to characterise the household's location. The years 1890, 1950-1970, 2000-2010 are missing.

In Figure 2, we plot our definition of intergenerational coresidence rate computed for two subsamples, one made of the households dwelling in rural areas, one made of the households dwelling in urban areas. The graph shows that the two series are very similar for what concerns both level and trend. This leads to conclude that the decline in intergenerational coresidence in the United States has been a general phenomenon, present in the rural as well as in the urban area on the country. This seems to exclude that the family choice of location has been the only factor at play, and leaves room for the mechanism based on relative income that we propose in this article.[23]

3 The model

3.1 Production

There are two sectors in the economy, agriculture (a) and industry (i), producing a final good Y with two different processes.[24] The production function in the agricultural sector is

$$Y_{a,t} = A_{a,t} \left(N_t h_{a,t}\right)^{\beta} \left(N_t l\right)^{1-\beta} , \tag{5}$$

where l stands for land per worker, $h_{a,t}$ for the hours worked per worker in sector a, in period t, and N_t is the number of workers. We assume that land is in fixed supply. The variable $A_{a,t}$ denotes total factor productivity (TFP) in agriculture, while $\beta \in (0, 1)$ denotes the labour-share in agriculture. The production function in the industrial sector is

$$Y_{i,t} = A_{i,t} N_t h_{i,t}, \tag{6}$$

[23]We model changes in relative income as changes in the functional distribution of income between rents and wages, due to the structural change out of agriculture. As such, our story is more directly applicable to rural areas. The decline of intergenerational coresidence in urban areas could be explained using the mechanism proposed by Pensieroso and Sommacal (2014) relying on the relative importance of technical progress with respect to the experience premium. That story and the current one are both stories of changes in the relative income of the different generations: changes in the functional distribution of income here; changes in the relative human capital of the young in Pensieroso and Sommacal (2014). In this article, we shall explore how much of the overall decline in intergenerational coresidence can be accounted for by changes in the functional distribution of income, ignoring other (possibly complementary) mechanisms affecting the relative income of the young.

[24]We model the structural change out of agriculture using a one-good model, like Doepke (2004) and Hansen and Prescott (2002). Alternatively, one could use a two-good model, like Gollin et al. (2002), which relies on non-homothetic preferences. In that model, the structural change out of agriculture depends on demand effects that would be hard to encompass in the model of intergenerational coresidence considered here.

where $A_{i,t}$ denotes TFP in industry and $h_{i,t}$ hours worked per worker in sector i. The aggregate production function for this economy is

$$Y_t = Y_{a,t} + Y_{i,t}. \tag{7}$$

The final good Y_t is the numeraire.

The production functions (5) and (6) are such that if the ratio $A_{a,t}/A_{i,t}$ is big enough, only the agricultural sector is operative. If instead the ratio $A_{a,t}/A_{i,t}$ is sufficiently low, then both sectors are operative. This asymmetry between the two sectors is explained by the fact that land is in fixed supply, implying that the marginal productivity of labour in agriculture goes to infinity when employment in the agricultural sector tends to zero.

Calling $w_{a,t}$ the wage in agriculture, $w_{i,t}$ the wage in industry and R_t the rent from land, profit maximizations in the two sectors implies

$$w_{a,t} = \beta A_{a,t} h_{a,t}^{\beta-1} l^{1-\beta}, \tag{8}$$

$$R_t = (1-\beta) A_{a,t} h_{a,t}^{\beta} l^{-\beta}, \tag{9}$$

$$w_{i,t} = A_{i,t}. \tag{10}$$

If both sectors are operative, labour mobility across sector ensures that $w_{a,t} = w_{i,t} = w_t$. If only the agriculture sector is operative, then the wage paid in the economy is $w_t = w_{a,t}$.

3.2 Households

The economy is populated by two overlapping generations of individuals living for two periods, the young, (y), and the old, (o). The size of each generation is ν, and it is constant over time.[25] In the first period, the agent is young and supplies inelastically one unit of labour.[26] He can work in both sectors.[27] He inherits the land from the old at the end of the period. In the second period, the agent is old and does not work. He earns the return on land and leaves the land to the young as bequest.[28] Each old has

[25]We abstract from changes in fertility (and longevity), as we want to isolate the effects of relative income on intergenerational coresidence.

[26]This implies that $\nu = N$, that is the number of workers coincides with the size of each generations.

[27]This implies $h_{a,t} + h_{i,t} = 1$

[28]In our model there is no market for land. Given that the price of agricultural land has been decreasing over the past two centuries in the United States (see Hansen and Prescott (2002)), results would qualitatively be the same, if we included a market for land. In fact, under the assumption that the old are the owner of land, the additional income on top of rents that the old would derive from selling land would be decreasing over time. Results available upon request.

the same amount of land, which, without loss of generality, is normalised to 1.

In each period, the young and the old can either live apart or coreside. We assume that the utility function of an agent of type $j = y, o$ is:

$$U(c_t^j, x_t^j; \delta) = \alpha \log c_t^j + (1-\alpha)\log x_t^j + \delta \log \kappa^j, \tag{11}$$

where c_t^j and x_t^j stands for consumption and housing services, respectively. We assume that housing services are a private good, if agents live alone, and a pure public good, if they live together. The price of x is denoted by p.[29] The variable κ^j measures the taste for living together.[30] The parameter δ is a dummy variable. It takes the values $\delta = 0$, if agent j lives alone, and $\delta = 1$ if the agents coreside.

If the young and the old live apart, they maximize $\hat{U}(c_t^j, x_t^j) \equiv U(c_t^j, x_t^j; 0)$ subject to their respective budget constraints

$$p_t x_t^y + c_t^y = w_t, \tag{12}$$

$$p_t x_t^o + c_t^o = R_t. \tag{13}$$

From the solution to this maximization problem we get the indirect utility functions for the case of non-coresidence, $\hat{V}_t^j$.

If the young and the old live together, resources are pooled together and their distribution is decided at the level of the household. We impose that the outcome of such a decision is efficient.[31] A way to characterize the set of all efficient outcomes is to maximize the weighted sum of the utility functions of the young and the old:

$$\max \theta_t \tilde{U}(c_t^y, x_t) + (1-\theta_t)\tilde{U}(c_t^o, x_t),$$

subject to

$$p_t x_t + c_t^y + c_t^o = w_t + R_t, \tag{14}$$

[29] We assume that x is produced using a linear technology $x = ZY^x$, where Y^x are the units of the final good Y used in the production of x, and Z is a productivity parameter. In equilibrium, $Z = \frac{1}{p}$.

[30] Notice that κ^j can be interpreted as cultural factors, altruism, or other non-observable characteristics of the individual. The presence of this element in the individual preferences allows in principle the model to rationalise other facts that we are not considering in this paper. For instance, if κ^j is higher when coresiding with relatives than with non-relatives, our model could be usefully used to rationalise why coresidence is mostly observed among relatives. This falls beyond the scope of our analysis.

[31] Accordingly, we are using a cooperative model of the family. As stressed by Browning et al. (2014), a cooperative approach seems a reasonable modelling choice in a context like the family, characterised by reasonably symmetric information and heavily repeated interactions.

where $\theta_t \in [0, 1]$ is the Pareto weight associated to the young, and $\tilde{U}(c_t^j, x_t) \equiv U(c_t^j, x_t; 1)$. From the solution to the maximization problem we get the indirect utility functions for the case of coresidence, $\tilde{V}^j(\theta_t, \kappa^j)$.

Notice that, as suggested by Browning et al. (2014), θ_t has a natural interpretation in terms of relative decision power of the young. If $\theta_t = 0$, the old acts as a dictator in the family. Increasing values of θ_t imply more "power" to the young. If $\theta_t = 1$, the young acts as a dictator in the family.

The choice of the living arrangement implies a comparison between the indirect utility of living alone, $\hat{V}_t^j$, and the indirect utility of coresiding, $\tilde{V}^j(\theta_t, \kappa^j)$. We define $\theta_{min,t}$ as the value of the Pareto weight of the young such that they are indifferent between living alone or with the old. For any $\theta_t > \theta_{min,t}$, the young prefer coresidence. By the same token, we define $\theta_{max,t}$ as the value of the Pareto weight of the young such that the old are indifferent between living alone or with the young. For any $\theta_t < \theta_{max,t}$ the old prefer coresidence. Imposing $\hat{V}_t^j = \tilde{V}^j(\theta_t, \kappa^j)$ for $j = (y, o)$, the formulas for $\theta_{min,t}$ and $\theta_{max,t}$ read:[32]

$$\theta_{min,t} = \left(\frac{w_t}{w_t + R_t} \frac{1}{\kappa^y} \right)^{\frac{1}{\alpha}}, \tag{15}$$

$$\theta_{max,t} = 1 - \left(\frac{R_t}{w_t + R_t} \frac{1}{\kappa^o} \right)^{\frac{1}{\alpha}}. \tag{16}$$

Since the young prefer coresidence when $\theta_t > \theta_{min,t}$ and the old prefer coresidence when $\theta_t < \theta_{max,t}$, coresidence is a Pareto improvement with respect to independent living if and only if $\theta_{min,t} < \theta_t < \theta_{max,t}$; for this to happen it must be that $\Delta_{\theta,t} \equiv (\theta_{max,t} - \theta_{min,t}) > 0$. In other words, when $\Delta_{\theta,t} > 0$, choosing coresidence as living arrangement can bring about a surplus of utility to be shared between the young and the old. As we assume that agents do not leave the possibility of a Pareto improvement unexploited, when $\Delta_{\theta,t} > 0$ coresidence will always be chosen.

Notice that the sign of $\Delta_{\theta,t}$ is the only information that is needed to characterize the coresidence choice. Indeed the possibility of coresidence rests on the existence of a surplus from coresidence. We do not need to compute how large the surplus is or its allocation among household's members. Accordingly, the model is silent about the ultimate determinants of the actual decision power θ_t (the sharing rule of the surplus).[33]

[32] Notice that $0 \leq \theta_{min,t} \leq 1$ holds if and only if $\frac{w_t}{w_t+R_t} \leq \kappa^y$. Similarly, $0 \leq \theta_{max,t} \leq 1$ holds if and only if $\frac{R_t}{w_t+R_t} \leq \kappa^o$.

[33] A similar approach was used by Iyigun and Walsh (2007) in the context of marriage.

Computing the difference $\Delta_{\theta,t} \equiv (\theta_{max,t} - \theta_{min,t})$ we find:

$$\Delta_{\theta,t} \equiv \theta_{max,t} - \theta_{min,t} = 1 - \left(\frac{1}{(1+d_t)\kappa^o}\right)^{\frac{1}{\alpha}} - \left(\frac{d_t}{(1+d_t)\kappa^y}\right)^{\frac{1}{\alpha}} \tag{17}$$

where $d_t \equiv \frac{w_t}{R_t}$.

As a consequence, living arrangements will in general depend on the taste for coresidence κ^j, on the weight of the public good in the utility function $(1-\alpha)$, and on the functional income distribution d_t. In particular, using equation (17), we can distinguish four cases, as in Pensieroso and Sommacal (2014).

1. $\kappa_j = 1$, for $j = y, o$. In this case, $\Delta_{\theta,t} > 0$ if and only if $(1-\alpha) > 0$. When both agents do not have a (negative or positive) taste for coresidence, they will coreside if only if they draw utility from the public good x_t.

2. $\kappa_j > 1$ for $j = y, o$. In this case, $\Delta_{\theta,t} > 0$ always. When both agents have a positive taste for coresidence, they will always coreside.

3. $\kappa_j < 1$ for $j = y, o$. In this case, there are two scenarios. If $(1-\alpha) > 0$, the sign of $\Delta_{\theta,t}$ cannot be established a priori: it depends on the relative income and on the strength of the negative taste for coresidence of the young and the old. When both agents have a negative taste for coresidence, they will coreside only if the utility they draw from the public good x_t is enough to compensate for their distaste for coresidence κ_j. This depends on the specific value of d_t. If instead $(1-\alpha) = 0$, then $\Delta_{\theta,t} < 0$ always. Absent the utility from the public good, when both agents have a negative taste for coresidence, they will not coreside.

4. $\kappa_y < 1$ and $\kappa_o \geq 1$; or $\kappa_y \geq 1$ and $\kappa_o < 1$. In this case, the sign of $\Delta_{\theta,t}$ cannot be established a priori: like in case 3, it will depend on the specific values of d_t, κ_y and κ_o. However, differently from case 3, coresidence might now be chosen even when $(1-\alpha) = 0$, i.e. agents draw no utility from the public good. In this case indeed, coresidence will be the chosen outcome if the agent who likes coresidence is ready to give up enough surplus to the agent who dislikes it to compensate the latter for his/her distaste for coresidence.

The key mechanism we use in the following sections to explain the change in living arrangements hinges on the relationships between: $\Delta_{\theta,t}$ and relative income d; relative income d and relative total factor productivity A_a/A_i.

Using again equation (17), it is possible to show that Δ_θ is decreasing in d_t if and only if[34]

$$\frac{\kappa^y}{\kappa^o} < d^{(1-\alpha)}. \tag{18}$$

Using Equations (8) and (9), the functional income distribution d_t can be written as

$$d_t \equiv \frac{w_t}{R_t} = \frac{\beta}{(1-\beta)h_{a,t}}. \tag{19}$$

When only the agricultural sector is operative, $h_{a,t} = 1$ and d_t is a constant. When instead both sectors are operative, wage equality across sectors ensures that

$$h_{a,t} = \left(\frac{\beta A_{a,t}}{A_{i,t}}\right)^{\frac{1}{1-\beta}}. \tag{20}$$

Therefore, d_t is a decreasing function of $A_{a,t}/A_{i,t}$.

3.3 The coresidence rate

At the individual level, coresidence is a binary choice: either the individuals live together, or they live apart. In order to have an aggregate coresidence rate, we introduce some degree of heterogeneity among agents belonging to the same generation. In particular, we shall assume that young agents differ for an unobservable idiosyncratic component affecting their taste for coresidence κ^y. More precisely, we assume that κ^y is a stochastic variable following a normal distribution truncated at 0, with mean μ and

[34] The condition in the text has an interesting interpretation in terms of income inequality. Suppose $\frac{\kappa^y}{\kappa^o} = 1$, i.e. young and old do not differ in their taste for coresidence. In that case, condition (18) reduces to $d > 1$. In other words, changes in the functional distribution of income that favours wages (the young) over rents (the old) will reduce the value of $\Delta\theta$ if and only if they increase an already existent inequality in favour of the young, or if $d > 1$. If not, i.e. if $d < 1$ and income inequality favours the old, then $\Delta\theta$ will decrease when d decreases, i.e. when the change in the functional distribution of income increases an already existent inequality in favour of the old. As we will explain in Section 3.3, given enough heterogeneity among agents, changes in $\Delta\theta$ map into changes in the aggregate coresidence rate. Accordingly, our model predicts a symmetric behaviour of coresidence with respect to the relative income of the young: loosely speaking, extreme values of d (high or low) will likely imply low coresidence, while intermediate values of d will likely imply high coresidence. It turns out that this is a general property of the coresidence model by Pensieroso and Sommacal (2014), which establishes a link between intergenerational coresidence and income inequality among generations that we are currently investigating.

standard deviation σ.[35] Each individual has a specific realisation of κ^y. For simplicity, we assume instead $\kappa^o = 1$ for all individuals.

As young individuals now differ in their preference for coresidence, Equation (17) becomes specific to any given young-adult pair. That is, for any generic household ι, coresidence will be chosen if $\Delta\theta_\iota > 0$. The sum for $\iota = 1, 2, \ldots, N$ of the households for which coresidence is Pareto efficient represents the number of multigenerational households in the economy. Accordingly, the economy-wide coresidence rate, π, will be the ratio between the number of intergenerational households and the total number of old persons, N. In formulas,

$$\pi = \frac{\sum_{\iota=1}^{N} I(\iota)}{N} \text{ with } \begin{cases} I(\iota) = 1 \text{ if } \Delta\theta_\iota > 0, \\ I(\iota) = 0 \text{ if } \Delta\theta_\iota \leq 0, \end{cases} \tag{21}$$

where I is an indicator function that takes a value 1 if coresidence is Pareto efficient for a given young-adult pair ι, and zero if it is not.

3.4 The industrial revolution

We assume that the TFP in the two sectors evolves according to the following law of motions:

$$A_{a,t+1} = (1 + \gamma_a)A_{a,t}, \tag{22}$$

$$A_{i,t+1} = (1 + \gamma_i)A_{i,t}, \tag{23}$$

where $\gamma_a < \gamma_i$ are the constant growth rate of TFP in agriculture and industry, respectively.

Following Hansen and Prescott (2002), we assume that at time $t = 0$ both technologies are available, but the productivity ratio $A_{a,0}/A_{i,0}$ is such that wages in the agricultural sector are strictly higher than wages in the industrial sector, and therefore only the agricultural sector is operative. For this condition to hold, it must be that

$$\frac{A_{a,t}}{A_{i,t}} > \frac{1}{\beta}. \tag{24}$$

The economy is then along a balanced growth path with a growth rate given by γ_a.

[35] Alternatively, we could have assumed that κ^y follows a log-normal distribution. Results from simulations with this alternative assumption are qualitatively and quantitatively similar to those presented in Section 4.2. Details available upon request.

As $\gamma_a < \gamma_i$, the ratio $A_{a,t}/A_{i,t}$ decreases over time and eventually passes the threshold level $1/\beta$. From then onwards, the industrial sector becomes profitable and therefore operative. The growth rate is equal to

$$\gamma_t = \frac{(1+\gamma_i)A_{i,t} + (1-\alpha)(1+\gamma_a)A_{a,t}\left[\alpha\frac{(1+\gamma_a)A_{a,t}}{(1+\gamma_i)A_{i,t}}\right]^{\frac{\alpha}{1-\alpha}}}{A_{i,t} + (1-\alpha)A_{a,t}\left[\alpha\frac{A_{a,t}}{A_{i,t}}\right]^{\frac{\alpha}{1-\alpha}}} - 1. \tag{25}$$

Asymptotically, the weight of the agricultural sector goes to zero and the economy is along a balanced growth path where the growth rate tends to γ_i.

3.5 The end of intergenerational coresidence

We assume that at time 0, $A_{a,0}/A_{i,0}$ is such that the coresidence rate π is high and positive. The idea is that in such a scenario, rents are high because the marginal productivity of land is relatively high. As time goes by, the ratio $A_{a,t}/A_{i,t}$ decreases, which implies that the functional distribution of income d_t increases (see Equation (20)). If Condition (18) holds for a majority of households, the assumed pattern for sectoral TFP implies that the difference Δ_θ decreases for most households as the economy undergo a structural transformation from agriculture to industry. Given the distribution of κ^y, Δ_θ may actually, and will in general become negative for some young-adult pair. Consequently, the aggregate coresidence rate π_t shrinks. As the structural change out of agriculture unfolds, the intergenerational coresidence rate keeps on shrinking, to eventually become zero.

4 The quantitative exercise

In this section, we run a quantitative exercise to verify to what extent the model outlined above is able to match the observed shift in the U.S. coresidence patterns documented in Figure 1. The objective is to quantify the strength of the mechanism outlined in the previous section. We shall limit our analysis to the period after 1870, so as to exclude the American civil war (1861-1865).

4.1 Calibration

In order to simulate the model, we need to assign numerical values to the structural parameters. Table 7 illustrates our choices. The 'Target' column reports the reference variable used for the calibration of each parameter. We interpret one model period to be 20 years.

Parameter	*Value*	*Target*
α	0.36	Share of private expenditures in 1929
β	0.5	Share-cropping contracts
γ_i	0.486	Trend growth of U.S. GDP in the XX century
γ_a	0.029	Trend growth of GDP in Western Europe, 1700-1820
κ^o	1	Homogeneity among old
μ	0.79	Coresidence rate in 1870
σ	0.4	Coresidence pattern

Table 7: Calibration of the parameters

The preference for private consumption, α, is calibrated so that the ratio between public goods and private goods in personal consumption expenditure in 1929 (the first year for which we have data) is 1.8, as reported by Salcedo et al. (2012). Because of our assumptions on preferences, this translate in the condition $(1-\alpha)/\alpha = 1.8$, which gives a calibrated value of 0.36 for α.

The value of the labor share in the agricultural sector, β, is in accordance with the typical share-cropping contract, which, according to Doepke (2004), allocates 50 percent of output to the land owner.

We set the initial conditions for the TFPs in the two sectors so that A_i is 1, and the ratio A_a/A_i is such that the model matches the data about the share of employment in agriculture in 1870.

The growth rate of TFP in the industrial sector, γ_i, is computed as the 20-years equivalent to an annual growth rate of 2%. This is the value of the growth of U.S. GDP in the XX century, according to Kehoe and Prescott (2002).

The growth rate of TFP in the agricultural sector, γ_a, is computed as the 20-years average growth rate of GDP per capita of a bundle of Western European countries between 1700 and 1820.[36]

As to the preference variables κ^j, we assume that κ^o is the same across all the old individuals and equal to 1, for simplicity. For what concerns the

[36]The countries are the Western Europe 12 group in Maddison (2011): Austria, Belgium, Denmark, Finland, France, Germany, Italy, Netherlands, Norway, Sweden, Switzerland and United Kingdom. We use those countries as representative of what GDP per capita was among colonists in the United States. For comparison, the value of γ_a in Hansen and Prescott (2002) is 0.03.

distribution of κ^y, its mean μ is calibrated to match the U.S. coresidence rate in 1870, which was equal to 64.43%. The standard deviation σ of the distribution of κ^y is a free parameter that measures the volatility of the taste for coresidence, which is an unobservable variable. A priori, we would like to have a small value of σ, for this would imply that we do not need a high degree of unexplained heterogeneity in unobservables in order to account for the data. We run several simulations of the model with different values of σ and choose the one that minimizes the average quadratic distance between the intergenerational coresidence rate in the model and the data. It turns out that the value of σ that gives the best performance of the model in terms of replicating the coresidence pattern is $\sigma = 0.4$.[37] This is a relatively low value compared to the standard normal distribution, suggesting that for our mechanism to work we effectively only need a small degree of unexplained heterogeneity.

4.2 Simulations

By construction, the model matches the coresidence and the employment rate in agriculture in 1870. Starting from 1870, we plug the values of γ_i and γ_a and run a numerical simulation. The objective is to study the evolution of the coresidence rate as the model economy witnesses a take-off from agriculture to industry.

Figure 3 (Panel I) shows the pattern of the coresidence rate in the model (blue line), and compare it with the data (red-dashed line). The model has the right qualitative behaviour, though it overestimates the initial drop in the coresidence rate. From a quantitative perspective, the model accounts for 71% of the observed drop in the intergenerational coresidence rate in 2010.

Given that our model provides a joint explanation of the shift from agriculture to industry and the change in the coresidence rate, the specific way in which we have modelled the structural change out of agriculture (i.e. à la Hansen and Prescott (2002)) might affect our results on coresidence. We are now going to explore the consequences of relaxing some aspect of the Hansen and Prescott structure.

We start by relaxing the assumption of a constant growth rate of TFP in both sectors, and in its stead we use TFP data from Alvarez-Cuadrado and Poschke (2011) as exogenous impulse mechanism for the model. Using these data, Alvarez-Cuadrado and Poschke (2011) argue that in the United States the structural change out of agriculture was mostly labour pull -

[37]For this value of σ, μ turns out to be equal to 0.79.

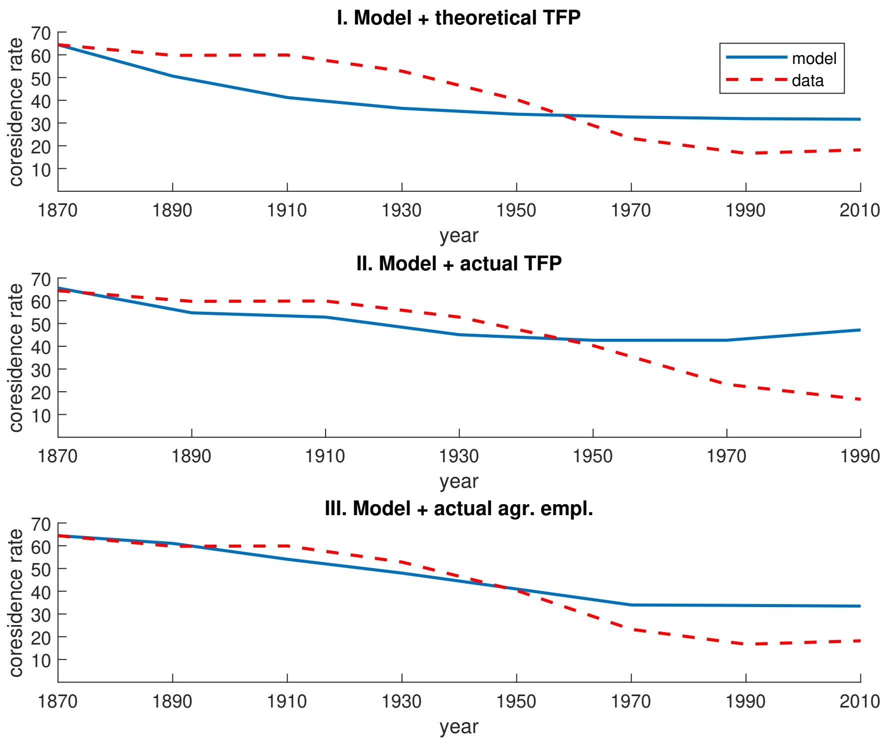

Figure 3: Simulations: intergenerational coresidence rate

i.e. driven by productivity increases in the industrial sector - till WWI and mostly labour push - i.e. driven by productivity increases in agriculture - after WWII.[38] In our model à la Hansen and Prescott (2002), on the other hand, the structural change out of agriculture is entirely labour-pull. So, we expect that by construction the model cannot reproduce the structural change after WWII, once we feed in the actual values of TFP.[39] Results from our simulations with TFP data are shown in Figure 3 (Panel II), and confirms this intuition.[40] The predicted value of the coresidence rate gets significantly closer to the data up to 1940, that is for the entire period in which, in the data as in our model, the structural change out of agriculture is labour-pull. After 1940, the relative TFP in agriculture increases, while the employment rate in agriculture still decreases in the data: the structural change becomes labour push. In this context, our model predicts a change of the functional distribution of income in favour of rents, and accordingly an increase in coresidence, which is at odds with the data.

As an additional exercise, we run a simulation in which employment in agriculture in each period is taken directly from the Census data. In this case, we are agnostic about the causes of the shift from agriculture to industry (i.e. we do not take a stance in the labour-pull/labour-push controversy), and just study its consequences in terms of income distribution and therefore intergenerational coresidence in our model. Results are shown in Figure 3 (Panel III). The model now tracks the data quite well for the overall period. It accounts for 67% of the observed drop in the intergenerational coresidence rate in 2010.

These results lead to the conclusion that the core mechanism of our model going from the structural change out of agriculture to the change in coresidence holds good qualitatively and is quantitatively relevant.

5 Conclusions

In this paper, we have shown that the structural change out of agriculture during the industrial revolution was a major determinant of the observed

[38] As explained in Alvarez-Cuadrado and Poschke (2011), the relative price of nonfarm and farm goods in the United States, which forms the bulk of their argument, is too volatile between WWI and WWII to be able to draw any conclusion about the underlying causes of the structural change.

[39] While this modelling choice has this obvious drawback, it has the advantage of allowing for a tractable integration between a multi-sectoral model of production and a general equilibrium model of intergenerational coresidence.

[40] The productivity data by Alvarez-Cuadrado and Poschke (2011) stop at 1990.

change in the family structure in the United States since the end of the 19th century.

We have built a two-sector model of the structural change from agriculture to industry à la Hansen and Prescott (2002) with endogenous intergenerational coresidence.

We have calibrated the model to the U.S. data. Results from the simulations show that first, the model has the right qualitative behaviour and, second, quantitatively the structural change out of agriculture can account for the 71% of the observed change in the coresidence pattern.

This paper is the first to explore the secular change in intergenerational coresidence from a quantitative macroeconomic perspective. It focuses on a particular mechanism, the change in the relative income of the young induced by the shift away from agriculture to industry. Other explanations are possible, including the introduction of Social Security, or the demographic transition. We leave the quantitative macroeconomic analysis of those hypotheses to future research.

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