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Shengmin Sun

Rigoberto A. Lopez

Xiaoou Liu

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Charles J. Zwick Center for Food and Resource Policy

Department of Agricultural and Resource Economics

College of Agriculture and Natural Resources

1376 Storrs Road, Unit 4021

Storrs, CT 06269-4021

Phone: (860) 486-2836

Fax: (860) 486-1932

ZwickCenter@uconn.edu

www.zwickcenter.uconn.edu

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Shengmin Sun

Center for Economic Research

Shandong University, China

Rigoberto Lopez

Department of Agriculture and Resource Economics

University of Connecticut

Connecticut, USA

Xiaoou Liu[1]

School of Agricultural Economics and Rural Development

Renmin University of China

Beijing, China

[1]Corresponding author: Xiaoou Liu at xiaoou.liu@ruc.edu.cn. Shengmin Sun is Professor, Rigoberto Lopez is Professor, and Xiaoou Liu is Associate Professor at the indicated institutions. The research is funded by the National Science Foundation of China (Project No. 71373268), and the Zwick Center for Food and Resource Policy at the University of Connecticut. We are grateful to Don Lien, Taoxiong Liu and participants at the 2nd international conference on the chinese economy: past, present and future holding by Institute of Economics and Institute of Innovation and Development of Tsinghua University.

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Abstract This paper evaluates the impact of property rights, labor mobility barriers and degrees of collectivization on China's agricultural growth in 1950-1978. Using a semi-Bayesian stochastic frontier analysis, we find that collective production with free labor mobility and private property rights was the most efficient institutional setting. Although deviations from the two institutions resulted in a decline in agricultural production, the loss in agricultural production from labor mobility barriers was up to five times greater than loss from depriving farmers of private property rights.

Keywords: economic growth, institutions, agriculture, property rights, labor mobility, China

1. Introduction

How institutional changes influence economic growth has been a longstanding question in the economic development literature. It is difficult to answer the question within a single country because it usually takes decades before the impacts of the evolution of institutions are realized. Acemoglu et al. (2001, 2008) partly solve the difficulty by comparing economic growth across countries with different institutions. However, empirically, this method requires controlling for factor endowments, cultural and historical factors that also impact growth.

China's institutional changes in 1950-1978 offer an excellent case study for analyzing the impact of economic institutions on agricultural output growth. During this period, China experimented naturally with combinations of property rights, labor mobility and increasing degrees of collectivization of agricultural producers. During this period, China was a closed economy containing only heavy industry and agriculture sectors, facilitating the isolation of the effects of institutional changes in rural areas. Such characteristics empirically solve the problem of slowly evolved institutions, without the requirement for controlling variables in a cross-section of countries.

Previous work on the effects of institutions on China's agriculture has focused on the great famine in 1959-1962 (Eckstein, 1966; Chinn, 1980; Ashton et al; 1984; Perkins and Yusuf, 1984; Lin, 1990; Kung and Lin, 2003; Li and Yang, 2005) or on agricultural productivity growth after economic reform in 1978 (Tang, 1980; Wen, 1993; Lin, 1992; Yang et al., 1992). With the exception of Lin (1990) and Li and Yang (2005), this literature

is devoid of a conceptual basis. Lin (1990) uses a game theory model that finds deprivation of the right to withdraw from communes to be a major contributor to the agricultural crisis. His analysis indicates that with the deprivation of withdrawal rights, cooperative behavior degenerated from a repeated game to a one-time game where households lack incentives to self-restraint, encouraging widespread shirking of work. He leaves the empirical test of his theory for later research. Li and Yang (2005), using a theoretical consumption framework, estimate a production function and find that the main cause of the great famine was misallocating millions of agricultural workers to steel production during the Great Leap Forward movement in the 1958-1962 period. They find that commune withdrawal right is not statistically significant in their empirical model, contradicting the main finding by Lin (1990).

This article systematically evaluates efficiency implications of step-wise economic institutional changes in China in the 1950-78 period through a semi-Bayesian stochastic frontier analysis. We decompose the institutional changes into four distinct sets of economic institutions: small household farming, elementary cooperatives, advanced cooperatives, and people's communes. These four institutions provide a national experiment as they vary by property rights, labor mobility barriers, and degrees of collectivization.

The analysis identifies the elementary cooperatives of 1954-1955 as the most efficient institution in the period under study. Specifically, we find that given the collectivization of agricultural production in the 1950-78 period, the first decrease in agricultural output was due to the deprivation of withdrawal rights of farm production

assets from collectives, creating a wedge between ownership and labor effort. However, the deprivation of withdrawal rights brought about a strict migration law under the Household Registration System created a more severe loss of agricultural output. The findings thus lend support to the upsurge of China's agriculture collectivization movement in recent years, releasing labor mobility restriction and respecting individual property rights, i.e., in the reconfiguration of elementary cooperatives. This paper reconciles the contradictory findings of Lin (1990) and Li and Yang (2005) by illustrating the causal relationship between withdrawal rights deprivation and labor resource misallocations. We find that the misallocation of labor is directly caused by the deprivation of farmers' right to withdrawal from commune under the strict migration law of the Household Registration System in 1958.[2]

2. Collectivization Movements in China: 1950-1978

After China's new regime was established in 1949, the central government adopted a Soviet-style heavy industry-oriented development strategy as its main economic objective. In an environment of scarce capital accumulation, low agricultural productivity, and a closed economy, the agricultural sector was viewed as the logical choice for financing this strategy. However, the scattered and unorganized peasantry made collection of taxes on agricultural production difficult and costly (Lin et al., 1996). To facilitate tax collection in order to accelerate industrialization, the central planner started organizing the peasantry into agricultural cooperatives in 1952, culminating in 1958 with public ownership of

[2] The coefficient of withdrawal variable may be statistically insignificant because of high standard errors led by collinearity, which is generated by including two variables with a causal relationship in a single empirical equation model such as in Li and Yang (2005).

farmland and production assets and a household registration system that restricted the right to withdraw from a commune.

Following Lin (1990), Wen (1993) and the *History of China Communism Party* (2011), we categorize the institutions that existed during 1950-1978 into four institutional sets: small household farming, elementary cooperatives, advanced cooperatives, and people's communes. The characteristics of each set are shown in Table 1.

Table 1 is here.

The first institution, small household farming with individual-owned production assets and free labor mobility, existed in 1950-1953, when the economy was recovering from World War II and China's domestic war and the problem of lack of labor and production assets was widespread in the vast rural area. Chinese farmers voluntarily formed mutual aid groups with shared production resources to ensure the continuity of agricultural production. The scale of this collectivization is very modest, averaging only 3-4 households (Lin, 1990).

The second institution is elementary cooperatives, in which the production labor and assets of neighboring farms were combined but remained voluntary, and individual ownership and labor mobility were retained. The number of elementary cooperatives was increased 8-fold in 1954, from 15,000 to 114,000, followed by a 5-fold increase in 1955 to 633,000 cooperatives with the average number of households in each cooperative increasing from 18.1 to 26.7. The development of elementary cooperatives stopped in 1956 with the movement to third institution, advanced cooperatives. In October 1955, the Communist Party of China congress had passed the *Resolutions on the Issues of*

Agricultural Collectivization, which deepened agricultural collectivization. The main characteristic of this movement was to transfer the individual ownership of land, animals, machines and other production assets to the collectives, and it also allocated income based on work contribution. By the end of 1957, the number of advanced cooperatives had increased by 1,506 times, from 500 to 753,000, and the average number of households in advanced cooperatives increased from 76 to 159.

The fourth institution is the people's commune, a supra-cooperative that combined advanced cooperatives and restrictive labor mobility barriers. Free labor mobility was banned by the *Household Registration Regulation*, a restrictive migration law enacted in January 1958. The central planner gained complete power to allocate labor resources between industry and agriculture and to ensure labor supply in urban areas for industrial development. People's communes in rural China ceased to exist in 1978.

3. Empirical Model and Estimation

The empirical framework utilized in this study involves a stochastic frontier analysis. One advantage of this approach over cost, supply, and profit functions is that it does not have to deal with market imperfections that affect prices. Following Coelli, Perelman and Romano (1999), a second-degree approximation to a stochastic frontier production function can be represented by a truncated translog form given by

$$\ln Y_{it} = \alpha_0 + \alpha_1 t + \sum_j \beta_1^j \ln x_{ijt} + \sum_j \beta_2^j \ln x_{ijt} t + \alpha_3 t^2 + \sum_{k=1}^{3} \gamma_k I_{kt} + \sum_{l=1}^{6} \zeta_l d_l + v_{it} + \varepsilon_{it}, \quad (1)$$

where $\ln Y_{it}$ is the natural logarithm of the value of agricultural output in province i in year t.

The variable t is a time trend variable that measures neutral technological changes

over time; x_{ijt} is a vector of production inputs j. Following Fan (1991), we include eight input variables: labor, sown area, chemical fertilizer, manure fertilizer, machinery, draft animals, irrigation area and government expenditures on agriculture. Labor in agriculture is measured by the numbers of people employed in a rural area. Land is measured as acreage. Manure fertilizer is very important for Chinese agriculture, so we calculate a variable to measure animal and human waste according to the formula proposed by Fan (1991). Total chemical fertilizer and Draft animals are measured at year-end. The latter is measured in units of 10,000 heads used for agricultural activities and rural transportation. Irrigation is measured as irrigated areas. Machinery input is measured by total horsepower used in agriculture at year-end. Following Huang (2005), we also include government expenditures to account for supportive policies and subsidies (Huang et al., 2005).[3] The main data source is *China Compendium of Statistics: 1949-2008*, supplemented by the government expenditure estimations of Huang et al. (2005).

This paper use three dummy variables I_{kt} to depict the institutions sets discussed in the theoretical model, using the people's commune system as a benchmark for comparison since it is in principle the least efficient (1958-78). Let $I_{1t}=1$ represents a system of small household farming (1950-1953), $I_{2t}=1$ elementary cooperatives (1954-1955), and $I_{3t}=1$ advanced cooperatives (1956-1957).

To capture unobserved regional fixed effects, we divide the country into seven

[3] In the reduced empirical model, it is necessary to take weather changes into account. Most of previous studies include the ratings of weather national-wide by setting best weather equal to 5 and worst weather equal to 1. We did not find detailed panel data to describe weather and therefore directly include weather in the one-side inefficiency measurement by assuming zero effect of the best weather and negative effects for any weather condition worse than the best.

regions: (1) Northeast region including Heilongjiang, Liaoning and Jilin; (2) North region including Beijing, Tianjin, Hebei, Henan, Shandong, Shannxi, Shanxi, and Gansu; (3) Northwest region including Neimenggu, Ningxia, Xinjiang, and Qinghai; (4) Central region including Jiangxi, Hunan, and Hubei; (5) Southeast region including Shanghai, Jiangsu, Zhejiang, and Anhui; (6) Southwest region including Sichuan, Chongqing, Guizhou, and Yunan; (7) South region including Guangxi, Fujian, Hainan, and Guangdong.[4]

Table 2 lists the summary statistics of the sample. The sample is a balanced panel of 30 provinces over 29 years, resulting in 870 observations.

Table 2 is here.

Inefficiency The assumption of a one-sided random variable has been a critical issue throughout development of the empirical model. The most frequently used assumptions are half-normal distribution (Aigner et al, 1977) and exponential distribution (Meeusen and van den Broeck, 1977). Under such specific distribution assumptions, the parameters could be estimated through maximum likelihood. Van den Broeck et al (1994) compute Bayes factors between these models under a Bayesian parametric framework. An advantage of Bayesian analysis is to reduce restrictions for estimation by incorporating parameter uncertainties through weighing mixtures of posterior distributions. Van den Boreck et al (1994) argues that unless the model has some special requirements, Bayesian estimation could generally be used efficiently. In the case at hand, the main disadvantage

[4]Chongqing became independent from Sichuan province and became a municipality. Hainan became independent from Guangdong in 1988. In *China Compendium of Statistics: 1949-2008*, the data even before 1978 includes Chongqing and Hainan. We have consulted with the National Bureau of Statistics about the problem. The data has been adjusted to fulfill current provincial district even for data before 1978. Tibet is excluded from our sample because of missing data.

of parametric Bayesian models is to impose parametric assumptions on the one-sided inefficiency measures. The restrictions will affect the efficiency of Bayesian inference (Griffin and Steel, 2004).

To solve the limitation, this paper applies the semi-parametric Bayesian method proposed by Griffin and Steel (2004) to estimate a stochastic frontier model. This method incorporates a Dirichlet process as the nonparametric Bayesian prior (Ferguson, 1973) into semi-parametric models using a hierarchical framework. The model is then fitted using a Markov chain Monte Carlo sampler algorithm. Let v_{it} in equation (23) be a one-sided random variable to measure inefficiencies during production and follows a Dirichelet process prior:

$$v_{it} \sim \mathrm{DP}(MH)$$

Where M is the Mass parameter of the Dirichelet process and H is the Dirichelet Centering distribution. The second random variable ε_{it} measures unobserved stochastic factors that shift the production frontier, which follow a normal distribution $\varepsilon_{it} \sim N(0,\sigma^2)$.

The issue of endogenous institution (Acemoglu, 2001; 2008) at least partially addressed because dummy variables are used to denote different institutions. Thus, changes of institutions fixed within periods and not related to changes of production. Besides, the central planning characteristics of China's economy at that time could also help to partly eliminate the endogeneity problem in the empirical framework.

4. Empirical Results

The parameter estimates of the production frontier are presented in Table 3. Table 3

shows that the mean impact of the small household farming institution (relative to people's communes) is 0.0885 with a standard deviation 0.1735. However, the impact of small household farming on agricultural output is not statistically different from that of the people's communes system. A potential explanation is that small household farming existed only in the recovery period of the war with possible discontinuities in agriculture production, making its effect be non-identifiable. The parameter estimates for the impact of elementary cooperatives and advanced cooperatives are 0.2282 and 0.1768, respectively. The estimates are statistically different from 0 and indicate that people's communes are Pareto dominated by elementary and advanced cooperatives. However, advanced cooperatives are Pareto dominated by elementary cooperatives, which is consistent with theoretical findings.

Table 3 is here.

Figure 1 shows the nonparametric kernel density distribution of the three coefficient estimates. Institutional effects are captured using statistics such as mean, standard deviation, median, and the first and third quartiles, to describe distributions of the random coefficient g_k for institution variables. The estimated statistics for γ_1 indicate that the distribution of institution variables in 1950-1953 is more dispersed than in the other estimates. The γ_2 and γ_3 distributions are more condense with most of the estimates falling within the one standard deviation region.

Figure 1 is here.

Table 4 computes the efficiency loss in gross agriculture value from the people's commune institution, compared with elementary and advanced cooperatives in 1958-1978.

We define efficiency loss of people's communes as the difference between real output and counterfactual output. The calculation includes two steps. The first step is to assume the elementary cooperatives and advanced cooperatives last till 1978 and calculates the corresponding counterfactual gross agriculture output under the two institutional sets, respectively. The results are shown in column (3) and column (5). The second step is to calculate the difference between real output and counterfactual output, as shown in column (4) to be efficiency loss compared with elementary cooperatives and column (6) to be efficiency loss compared with advanced cooperatives. The data used for calculation are mean values of the variables over entire sample.

Figure 2 draw the data from column (2), column (3) and column (5) as the predicted/counterfactual gross agriculture value against actual value in Table 4. The diamond line presents actual output under the people's communes during 1958-1978. The squared and triangle lines represent predicted output under elementary cooperatives and advanced cooperatives, respectively. Figure 2 shows that the distance between elementary and advanced cooperatives is far smaller than that of the two cooperative institutions compared to people's communes. For example, the maximum value difference between elementary and advanced cooperatives is 0.345 billion Yuan, which is only 5% of predicted production under the elementary cooperative institution, and 16.6% of the maximum difference between elementary cooperatives and advanced cooperatives. The results indicate that the first deprivation of private property rights causes maximally only a 16.6% loss in production decreases. The second deprivation of withdrawal from communes leads to a 83.4% decrease. That is, the efficiency loss of misallocating labor

thereby is maximally 5.02 times more significant than deprivation of property rights. The main damage of people's communes to production is the central planner's misallocation of labor.

Figure 2 is here.

5. Conclusions

This paper discusses the impact of different institutions on agriculture growth, using China 1950-1978 as a case study. The empirical findings show that, elementary cooperatives spontaneously formed by farmers from 1954 to 1955 are an efficient institution. Under this institution, households can share skills and knowledge of farming. Households keep their private property rights to land and farming tools and associated outcomes. This institution increases the total labor supply of the society and effectively avoids monitoring cost by eliminating the possibility of shirking work. This finding provides a rationale for the current upsurge of farm cooperatives in China.

The third conclusion is that, the efficiency loss of people's communes mainly came from the central planner's misallocation of labor resources between two sectors. This finding is consistent with Li and Yang (2005) but offers additional insights. It reveals that the source of reduced production is the central government's labor allocation power, gained by imposing a restrictive immigration law to deprive household's right of withdrawal from communes and free movement between sectors. The economy with prohibited labor migration is highly volatile. The production loss of people's commune caused by household registration system has shown a long-lasting and enormous efficiency loss. The economic reform since 1978 provides a good proof for this finding by

unofficially releasing the labor mobility barriers, when the labor market regained the power of invisible hand to optimally allocate labor between different sectors and triggered a new surge of rapid economic growth.

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Table 1. Four sets of economic institutions in rural China: 1950-1978

Name	Time of existence	Property rights of production assets	Collective production	Labor Mobility
Set 1: small household farming	1950-1953	Individual owned	No	Not Restricted
Set 2: elementary cooperatives	1954-1955	Individual owned	Yes	Not Restricted
Set 3: advanced cooperatives	1956-1957	Public owned	Yes	Not Restricted
Set 4: people's commune	1958-1978	Public owned	Yes	Restricted

Table 2. Definition and Summary Statistics of the Variables in the Sample

Notation	Definition	Unit	Mean	Min.	Max.	Std. Dev.
Y_t	Gross Agricultural Value	Billion Yuans	2.84	0.00	10.59	2.37
x_1	Rural Labor	10,000 persons	788.02	42.97	2624.49	600.20
x_2	Sown Area	1000 hectares	4828.94	347.68	14610.67	3244.04
x_3	Chemical Fertilizer	10,000 tons	20.17	0.00	371.75	42.60
x_4	Manure Fertilizer	10,000 tons	25.73	0.56	78.69	17.68
x_5	Machinery	10 Kilowatts	78.16	0.00	1084.57	147.74
x_6	Draft Animals	10,000 heads	269.48	6.20	783.90	177.03
x_7	Irrigated Area	1,000 hectares	1005.33	0.00	4414.81	876.63
x_8	Government expenditures on Agriculture	Billion Yuans	0.06	0.00	0.47	0.07
I_1	Small household farming	dummy variable	0.14	0.00	1.00	0.35
I_2	Elementary cooperatives	dummy variable	0.07	0.00	1.00	0.26
I_3	Advanced cooperatives	dummy variable	0.07	0.00	1.00	0.26

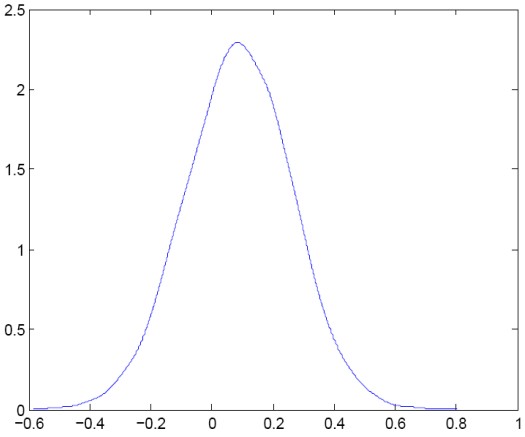
Table 3. Coefficient Estimates

Variables	Means	Std. Dev.	Variables	Mean	Std. Dev.
Inputs:			Input $\times t$:		
Rural Labor	0.0837	0.1387	Rural Labor $\times t$	-0.0086	0.0064
Sown Area	0.3986	0.1167	Sown Area $\times t$	0.0116	0.0065
Chemical Fertilizer	-0.0099	0.0270	Chemical Fertilizer $\times t$	0.0027	0.0018
Manure Fertilizer	0.8034	0.3074	Manure Fertilizer $\times t$	0.0294	0.0181
Machinery	0.0700	0.0266	Machinery $\times t$	-0.0065	0.0029
Draft Animals	-0.6035	0.2508	Draft Animals $\times t$	-0.0211	0.0137
Irrigated Area	0.2429	0.0533	Irrigated Area $\times t$	-0.0116	0.0033
Government expenditures on Agriculture	-0.2081	0.0424	Government expenditures on Agriculture $\times t$	0.0120	0.0037
Institutional dummies:			Regional dummies:		
Small household farming	0.0885	0.1735	Northeast	-0.3169	0.1296
Elementary cooperatives	0.2282	0.1253	North	-0.4081	0.0831
Advanced cooperatives	0.1768	0.0994	Northwest	-0.5410	0.1216
Time Variables:			Central	-0.3915	0.0917
t	0.1617	0.0608	Southeast	-0.2834	0.1053
t^2	-0.0011	0.0010	Southwest	-0.2209	0.0820
Frontier variables:			Constant:		
σ^2	0.2219	0.0154	C	-2.4827	0.9214
λ	14.3139	3.7475			

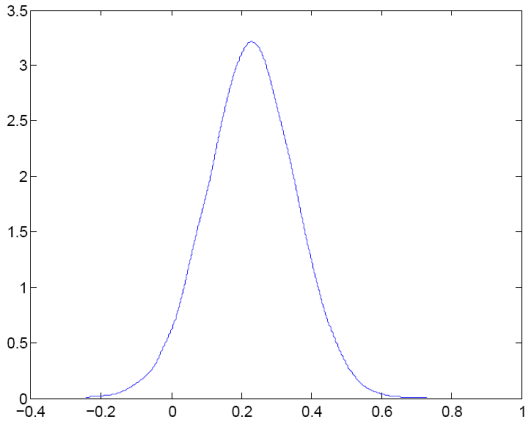
Table 4. Efficiency Loss of the People's Commune Institution in Billion Yuan

Year (1)	Actual Output (2)	Elementary Cooperatives		Advanced Cooperatives:	
		Output (3)	Differences (4)	Output (5)	Differences (6)
1958	2.205	2.611	0.406	2.48	0.275
1959	2.117	2.527	0.41	2.4	0.283
1960	1.884	2.703	0.818	2.567	0.683
1961	1.982	2.785	0.803	2.645	0.663
1962	2.192	3.083	0.891	2.928	0.737
1963	2.315	3.32	1.006	3.154	0.839
1964	2.516	3.606	1.09	3.425	0.909
1965	2.778	3.865	1.086	3.671	0.892
1966	3.088	4.125	1.037	3.918	0.83
1967	3.1	4.154	1.054	3.946	0.846
1968	3.032	4.172	1.14	3.963	0.931
1969	3.087	4.42	1.333	4.198	1.111
1970	3.412	4.806	1.394	4.565	1.153
1971	3.748	5.012	1.264	4.76	1.012
1972	3.793	5.31	1.517	5.043	1.25
1973	4.135	5.613	1.478	5.331	1.196
1974	4.236	5.737	1.5	5.449	1.212
1975	4.393	5.932	1.539	5.634	1.241
1976	4.394	6.171	1.777	5.862	1.467
1977	4.385	6.419	2.034	6.097	1.712
1978	4.802	6.87	2.068	6.525	1.723

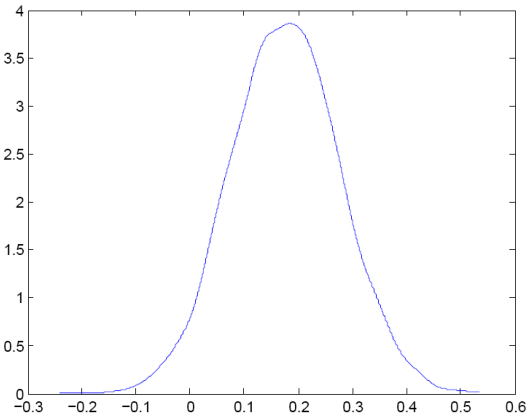
Figure 1. Kernel Distribution for Institutional Coefficients



Small Household Farming (γ_1)



Elementary Cooperatives (γ_2)



Advanced Cooperatives (γ_3)

Figure 2. Predicted/Counterfactual Output under Alternative Institutions: 1958-1978