Using Evolutionary Game Theory to Examine U.S. and EU Agricultural Policy Institutions

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Abstract: *A brief review of the history of agricultural policymaking in Europe and the U.S. reveals that major policy changes have often been brought about by major socio-political "shocks," such as the Great Depression and World War II. Such shocks also lead to the creation of institutions that tend to stay in place for long periods after the initial shock has passed. We use evolutionary game theory to model and simulate the effects of socio-political shocks on political institutions.*
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Introduction

A brief review of the history of agricultural policymaking in Europe and the U.S. reveals that major policy changes have often been brought about by major socio-political "shocks," such as the Great Depression and World War II. Such shocks also lead to the creation of institutions that tend to stay in place for long periods after the initial shock has passed. We use evolutionary game theory to model and simulate the effects of socio-political shocks on political institutions.

The development of agricultural policies through time: A literature review and some empirical examples

The intervention of government or the ruling class in the agricultural sector is as old as agriculture itself, since agriculture always has been a key element of economic wealth and political power, and important in leaders' and societies' struggles for survival. Before the industrial revolution, a ruler had to control agriculture to have a hand on the fate of the ruled. The aim of this section is twofold. First, we briefly discuss the long-term development of agricultural policies in the U.S. and Europe. Second, we focus on the impact major political and economic events on that development. Our analysis draws heavily on Benedict (1953), Tracy (1964), Cochrane and Ryan (1975), and Cameron and Neal (1989).

The feudal system dominated in Medieval Europe. Although it developed quite differently across Europe, feudalism was mainly characterized by a lord owning the land (and perquisites like mills or winepresses), and peasants cultivating the land. The lord influenced the agricultural sector by imposing levies, fees and taxes on the harvest in order to facilitate the operation of the feudal system and to raise his own standard of living. Other areas of intervention included the designation of property rights over land and labour, and inheritance laws. Using current terminology, agricultural policy was restricted to the legal system and the taxation system. Of course, long-distance agricultural trade in Medieval Europe was restricted to non-perishable commodities (e.g. spices, wine).

With the French Revolution of 1796, a revolutionary movement swept over large parts of Europe, resulting in the abolition of the feudal system that had prevailed since the Medieval times. The results for agriculture were quite different depending on the design of agricultural laws and the degree and direction of government intervention. In France, the majority of the feudal farms were broken up into small units. Supported by an inheritance law that required the equal division of the farm among heirs, an unprofitable small-scale agricultural structure arose. In Denmark, on the contrary, the government encouraged peasants to buy agricultural land. The average farm size was larger than in France, but smaller than in Britain.

A major economic event that had a lasting impact on the picture of agriculture was the Industrial Revolution starting in the first half of the 19th century. Before that time, European agriculture was characterized by free trade and a low level of governmental intervention compared to the current situation. Ever since then, the European agricultural sector has declined in terms of economic importance and employment. From an agricultural point of view, the industrial revolution had two major impacts: (1) capital-intensive production techniques released labour to be used in the growing industrial sector, and (2) transport became cheaper and gave ground to start trading commodities between countries and continents.[1] In effect, the agricultural sector faced pressure from two sides: outside competition and the ongoing replacement of labour by capital.

Both developments gave rise to protectionist policy measures at the end of the 19th century. Nationalistic ideology following the German-French War of 1870 favoured this trend. Agricultural

[1] Tracy (1964:22) reports that the freight rate for wheat from Chicago to London was more than halfed between 1870-79 and 1895-99.

policies were extended to include agricultural trade policies in general, and tariffs in particular. France introduced tariffs on livestock in 1881, which were raised until 1892 and remained stable until the First World War (Tracy, 1964: 27-28). Similar developments could be seen in Germany, Italy and Switzerland. A notable exception was Britain, which committed itself to free trade, partly because of the significant overseas trade with its colonies. In Denmark and the Netherlands, which also retained free trade principles, there was a shift from crop production to livestock production due to the increasing competition from overseas feed cereals.

A second wave of protectionism in general and tariff protection in particular occurred in the period following World War I. The causes were different. The Great Depression, with its falling commodity prices was an important factor. Some countries like Austria that had lost their productive agricultural regions in the First World War, tried to develop their own agriculture. The argument to achieve self-sufficiency in food products in times of war was heeded in many European countries. Even in Britain, tariffs for agricultural commodities were introduced in the 1930s.

It appeared, however, that tariffs as such were not sufficient to protect domestic agriculture from foreign trade, since "*exporters were prepared to sell at almost any price*" (Tracy 1964:122) during the Great Depression. For that reason the arsenal of agricultural policies was extended with non-tariff trade measures. Import quotas were established and extended in many European countries during the 1930s. Other policies to restrict trade were milling ratios (invented by Norway in 1927) and other regulations that linked domestic production and imports. Milling ratios required domestic mills to use a certain minimum percentage of home-grown cereals. Similarly, Latvia, Spain and Switzerland developed policies according to which a certain amount of domestically-produced commodities had to be purchased for each unit of the same commodity imported.

At the same time, agricultural policies emerged that directly intervened in agricultural markets, notably in the U.S., France and Germany. Contrary to the abovementioned trade measures, which often increased the state budget at the expense of higher food prices hurting consumers, direct intervention in domestic agricultural markets had to be financed by the state budget. The burden of agricultural support now included not longer only consumers, but also taxpayers. The French *Office National Interprofessionnel du Blé* was established in 1936 and was given the task to fix domestic wheat prices by governmental purchases, import regulation and export subsidies. Since Britain did not restrict trade with its colonies, trade measures had a lesser impact on markets compared to other European countries. Instead, deficiency payments were given to wheat and sugar-beet (Tracy 1964:125). Marketing boards and farmers' sales co-operatives were established in many European countries and contributed to retain farmers' power in the food value chain. A similar development, in which the government assisted private cooperatives, could be observed in the US (Hoffman and Libecap 1991). The U.S. Commodity Credit Corporation was formed in 1933, to support commodity prices as part of F.D. Roosevelt's New Deal (Gardner 1992: 85). Direct intervention in agricultural markets in the period between the two World Wars culminated in the fascist state of Germany. Self-sufficiency in food was an important aspect in preparation for the Second World War and the rural farm population fitted extremely well into the racial ideology.

The outburst of the Second World War constituted a major political and economic event. In its aftermath, ensuring that food production "match" domestic demand was a stated main priority for almost all European countries. To reach that goal quickly, government intervention measures that had been in place during the War were prolonged and even added on. More sophisticated policy instruments, like minimum prices for producers, were introduced. In addition, new production technologies and farm advisory systems, subsidized by the government, contributed to a rapid rise of agricultural output. Agricultural trade within Europe became gradually more restricted than in the Pre-War period. This development led to discussion on the establishment of a common European agricultural market in the 1950s (Henrichsmeyer and Witzke 1994:544). National agricultural policies

in Western European countries eventually were harmonized through the Common Agricultural Policy (CAP) of the European Economic Community (EEC). The EEC and the CAP can be seen as a direct consequence of the Second World War.

The history of the development of agricultural policies in Europe and the US shows common patterns. First, the arsenal of agricultural policies grew and became more sophisticated through time. Starting with policies that hardly influenced production decisions or agricultural trade, many policies today significantly distort agricultural production and trade. In this respect, the latest (albeit halting) policy reform steps undertaken by the EU and U.S. together with a worldwide pressure to liberalize agricultural trade through the WTO may indicate the beginning of a shift away from production- and trade-distorting policies. If this development continues in the future, one could image a situation not unlike that of European agriculture before the Depression of 1880-1900.

Second, once specific agricultural policies were in place, they were hard to remove. The first and the second patterns are closely linked together. Once governments intervene in markets through distortionary policies, farmers are to a lesser extent exposed to market forces. As a result, costly production tends to exceed demand, structural adjustments slow down, and prices and incomes fall. Drawing on the example of price support, Tracy (1964: 368) concludes that "*by maintaining or stimulating uneconomic production, [price supports] have perpetuated the need for their own existence*". In Norway, the number of agricultural policy instruments grew from 13 in 1960 to more than 100 in 2000 (Sagelvmo 2000: 71).

Third, the change in agricultural policies can be attributable to governments' reactions to single global events that either worsen the relative economic conditions of the farm sector (economic events like the Great Depression) or threaten food security (political events like wars). As such, agricultural policies rather tend to "*satisfy* (…) *farmers with short-term benefits than to embark on long-term programmes of structural reform*" (Tracy 1964: 369). As there is no immediate global crisis today, the ongoing agricultural reforms in the EU and the U.S. may be understood as a *ceteris paribus* return towards some "long-term equilibrium" characterized by agricultural policies that minimally distort production decisions or trade which has prevailed in Europe until the first wave of protectionism of 1880-1900.

Table 1. Synopsis of the evolution of agricultural policies

Time period/Event	**Europe**	**US**
Medieval Europe	Property rights, legal system, system of taxation	-
French Revolution	Diverging agricultural structure	-
First wave of protectionism: Depression of 1880-1900	Tariffs Agricultural co-operatives	Tariffs Agricultural co-operatives
Second wave of protectionism: Depression of 1930s	Non-tariff trade measures (import quotas, milling ratios) Market intervention (Marketing boards, deficiency payments)	Non-tariff trade measures Market intervention
Second World War	Wide range of trade measures Sophisticated market intervention	Wide range of trade measures Sophisticated market intervention

Figures 1 and 2 illustrate the development of government outlays for agriculture in Norway and the U.S. over approximately the the last fifty years (Norway: 1959-2004, US: 1955-1989)[2]. It appears that agricultural outlays developed cyclically in the U.S., but more smoothly in Norway. Between 1955 and the mid-1970s, outlays were stable and varied in the range of $5 billion and $10 billion in the US. In the following period until the mid-1980s, outlays increased considerably, although the cyclical character of the payments remained. The government outlays reached a peak in 1986, and declined thereafter.

The development of government outlays to agriculture in Norway can be divided into three main periods. The first period from 1959-1974 was characterized by slowly increasing outlays. At the beginning of the second period in 1974, the parliament agreed upon the objective to close the gap between the incomes for industrial workers and the agricultural incomes measured on a man-years basis. As a tool to close the gap, governmental outlays and consumer outlays (increased administrative market prices in the shadow of prohibitive import restrictions) were heavily increased. The policy was in place between 1975-1989. It then became obvious that farm incomes could not be maintained permanently at the industrial worker level without significant long-term annual increases in government outlays. The third period started in 1990 by reforming agricultural policies. Market prices were reduced and compensated by direct payments (not unlike the CAP-reform of 1992). This boost government outlays in the early 1990s reached a peak in 1992. Government outlays for agriculture have since declined, but are still higher than at the end of the second period.

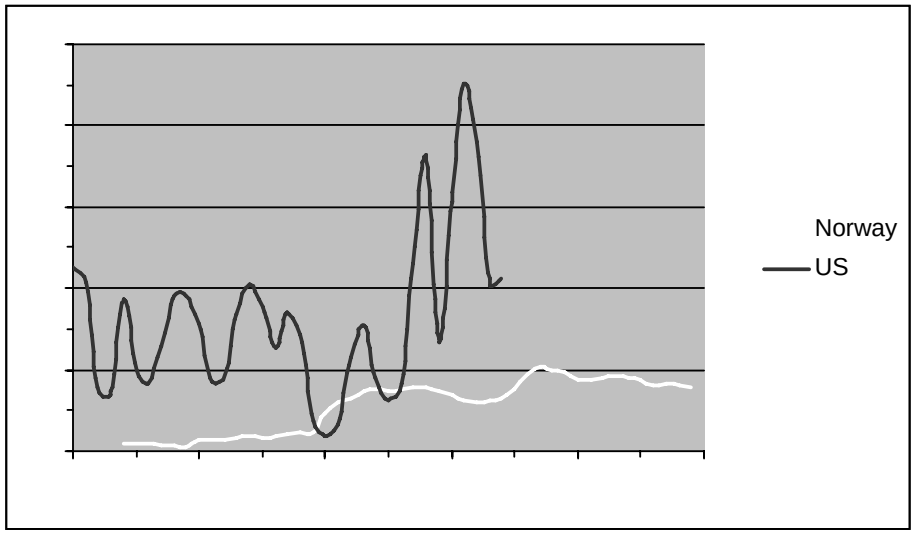

Figure 1. Government outlays for agriculture in Norway and the US (national currencies at 1982-prices)
Notes: US: Governmental outlays in price support programs, principally for direct deficiency payments, acquisition of stocks, payments for voluntary holding acreage idle, and storage subsidies. Norway: Direct and other payments to farmers.
Source: US: Gardner (1992:86), Norway: NILF (var.iss.)

[2] Norway (rather than the more populous EU) is chosen because it is one of few remaining countries in Europe still having its own national agricultural policy. Measuring accurately the total outlays of the CAP over such a long period is an intricate and time-consuming task as intervention takes place a both the EU-level and the national level (often even at the sub-national level), and policies have shifted quite significantly during this period.

Figure 2 makes use of the same data used in figure 1, but presents them in a slightly different way. In order to highlight the variations of government outlays across years, the year-to-year percentage change in outlays to agriculture are calculated. Figure 2 reinforces the patterns of figure 1 by illustrating the cyclical movements in the US and the periods of considerable increase in governmental outlays in Norway.

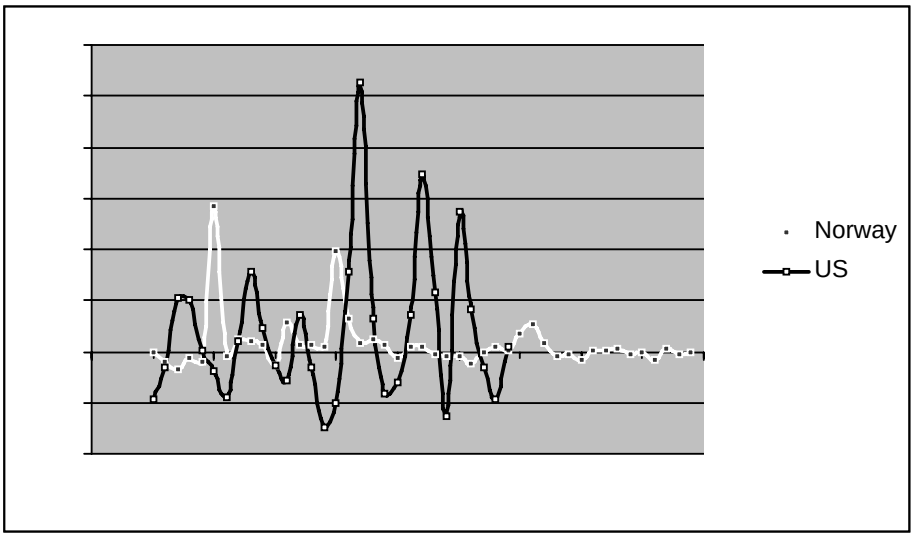

Figure 2. Year-to-year percentage change in government outlays for agriculture in Norway and the US
Notes and sources: see figure 1

Using an evolutionary game theory model to conceptualize agricultural policy history

From the historical review above we derive the hypothesis that major socio-economic events ("shocks"), such as the French Revolution, or the Great Depression/World War II may lead to rapid changes in agricultural policy. Moreover, policy changes implemented in the wake of a shock often remain in place for long periods of time after the shock is over. For example, many of the aspects of Depression-era policies implemented in the U.S. remain in today (Cochrane and Ryan, 1975). Various theoretical political-economic explanations have been put forth to explain why large economic and social changes might lead to policy changes (e.g., Becker, 1985, Bullock 1992). But another question arises: why should a policy change brought about by a "shock" remain in place even after the shock is decades past? In this section we use evolutionary game theory to approach this question. We build a model that shows how an institution (or "convention") brought about by a shock can outlast the shock.

An adaptive learning model based on a Becker-type non-cooperative game

Following but simplifying Becker (1983), imagine a political economy in which two interest groups compete, applying political pressure in a non-cooperative game. Political pressures in the Becker model move a (black box) government to tax one group and subsidize the other with the proceeds. In Becker's model, payoffs are continous functions of strategy variables (political expenditures), and the set of feasible strategies is the nonnegative part of the real number line (political expenditures can be any nonnegative amount). Here we employ a simpler version of the Becker model, one in which each political pressure group has only two feasible strategies: low

political expenditures and high political expenditures. We assume the two groups playing the game are non-farmers and farmers. We bypass the details of the Becker model involving political pressure functions, dead weight losses, and political influence functions, and simply assert that in normal periods farmers and nonfarmers meet to play a Nash non-cooperative game *G*, shown in normal form in Table 3.

Table 3. The basic game, *G*, in normal form.

	Non-farmer plays high political expenditures, H	*Non-farmer plays low political expenditures, L*
Farmer plays low political expenditues, l	(3.0, 6.0) Risk dominant Nash equilibrium	(5.1, 5.0)
Farmer plays high political expenditures, h	(2.0, 2.1)	(6.0, 3.0) Risk dominated Nash equilibrium

In Table 3, the farmer is the row player, and the non-farmer is the column player. The farmer can choose between two strategies: low political pressure *l*, or high political pressure *h*. Similarly, the non-farmer can choose low political pressure *L* or high political pressure *H*. As in Tullock (1980), Coggins (1995), and Bullock and Rutström (2004), political expenditures can exceed the size of the government subsidy: if both groups place high amounts of political pressure, their political efforts cancel each other out, and payoffs are only (2.0, 2.1). Still, given that the other player has a low amount of political expenditure, a player may increase his payoff by switching his strategy from low to high. The game *G* has two pure Nash equilibrium strategy profiles: (*l*, *H*) and (*h*,*L*). The risk-dominant Nash equilibrium strategy profile is (*l*, *H*) (Young, 1998, pp. 66-68). We may think of this as being in some sense the "normal" equilibrium. That is, game *G* reflects a political economy in which, at least in some sense, we can expect farmers make low political expenditures and non-farmers make high political expenditures. Of course, it is not immediately apparent that in Europe and the U.S., this is the political economy outcome we are observing in the current reality. Rather, casual observation tells us that in Europe and the U.S., farmers are placing high amounts of political pressure relative to that placed by non-farmers. (In making this statement we are ignoring many important aspects of political pressure, such as group size, and free-riding costs (Gardner 1987).) We propose, however, that since the shock of the Great Depression/World War II, the U.S. and Europe have not been in the "normal" political economic equilibrium of (*l*, *H*). Rather, these political economies have been stuck for decades in the risk-dominated Nash equilibrium, (*h*, *L*), in which farmers have been making high political expenditures, and non-farmers have been making low political expenditures. We argue that because of a type of institutional inertia, "shocks" can affect political economies for many periods after the shock has taken place.

Our arguments are dynamic. We expand the one-shot non-cooperative game *G*, making it a recurrent game. That is, *G* will serve as the basis for our evolutionary game theoretical model, which in particular is an adapative learning model (Young, 1998). Evolutionary game theory has been used to explain the existence of social conventions or institutions, such as why in some countries everyone drives on the right side of the road, while in others everyone drives on the left, or why and how neighbourhoods might become ethnically segregated. In evolutionary game theory agents operate with limited information, and remember and sample only a fraction of past play in order to form subjective probabilities about future play. Here we will attempt to use evolutionary game theory to explain the institutional inertia of agricultural policy.

Our model builds upon the one-shot game *G*, but assumes that *G* is played recurrently. It is common to assume in evolutionary game theory that in each period, representative players from each role or group (here farmers and non-farmers) meet to play the basis game (here *G*). In each discrete

time period, one player is drawn at random from each of the two groups, and these two players play *G*. Each player develops a simple statistical model to predict what the other player will do, based on fragmentary information of what members of that other group have done in the recent past. For the purposes of our illustration, we assume that the players all have *memories* of length $m = 5$ periods. For example, say that the game is ten periods old, and that the column player (the non-farmer) has made the following moves, respectively, in periods 1 through 10: {*L, L, H, L, H, H, L, H, L, L*}. Then we assume that the row player (the farmer) would only be able to remember the latest five moves of the opposing group: {*H, L, H, L, L*}. If farmers had played {*l, l, h, h, l, h, h, h, l, h*} in the first 10 periods, then non-farmers would only have a memory of the last five moves: {*h, h, h, l, h*}. Furthermore, we assume that both players take a random sample of size $s = 2$ from the opponents' remembered moves (their "history"), from which they calculate the probabilities of the opponents' next moves. If, for example, the farmer took sample {*H, L*} from history {*H, L, H, L, L*}, then because 50% of non-farmers' sampled plays were *H*, the farmer assumes that there is a 50% chance in the next period that the non-farmer's move will be *H*, and a 50% chance that it will be *L*. The farmer then uses these estimated probabilities and the payoff matrix of *G* to calculate expected utility from each of his potential moves, which would be,

$$EU_f(l) = 0.5u_f(l,H) + 0.5u_f(l,L) = 0.5(3.0) + 0.5(5.1) = 4.05 \quad (1)$$

$$EU_f(h) = 0.5u_f(h,H) + 0.5u_f(h,L) = 0.5(2.0) + 0.5(6.0) = 4.00\,. \quad (2)$$

In one form of our evolutionary game, we assume that players never make mistakes, and therefore always choose that move which provides the highest level of expected utility. So, in this errorless form of the game, the farmer would choose to play *l* in period 11, since 4.05 > 4.00. Similarly, if the non-farmer's sample from history {*h, h, h, l, h*} were {*h, h*}, he would estimate a probability of zero that the farmer will play *l* next period, and a probability of 1.00 that the farmer will play *h*. His expected utility from each of his potential strategies is

$$EU_n(H) = 0u_n(l,H) + 1.0u_n(h,H) = 0(6.0) + 1.0(2.1) = 2.1 \quad (3)$$

$$EU_n(L) = 0u_n(l,L) + 1.0u_n(h,L) = 0(5.0) + 1.0(6.0) = 6.0\,. \quad (4)$$

The non-farmer in this example would maximize expected utility by playing *L*, since 6.0 > 2.1.

Up through period 11, then, the farmers will have played {*l, l, h, h, l, h, h, h, l, h, h*} of which the most recent five plays {*h, h, l, h, h*} will be in the non-farmers' memory in period 12. Similarly, the non-farmers will have played {*L, L, H, L, H, H, L, H, L, L, L*}, of which {*L, H, L, L, L*} will be in the farmers' memory.

A *state* in our game is a set of five joint strategies. For example, { (*l, L*), (*h, L*), (*h, H*), (*h, H*), (*l, H*) } is a state. The states { (*l, H*), (*l, H*), (*l, H*), (*l, H*), (*l, H*) } and { (*h, L*), (*h, L*), (*h, L*), (*h, L*), (*h, L*) } are *absorbing states*. To see why, assume that the current state is { (*l, H*), (*l, H*), (*l, H*), (*l, H*), (*l, H*) }. Then the probability is 1 that the farmer will pull a sample (*H, H*) and that the non-farmer will pull the sample (*l, l*). Since the farmer's best response to (*H, H*) is *l*, and non-farmer's best response to (*l, l*) is *H*, then with probability 1 the state in the following year will again be { (*l, H*), (*l, H*), (*l, H*), (*l, H*), (*l, H*) }. Thus, if an absorbing state is entered in the game as described so far, it can never be left. The joint strategy profile that makes up an absorbing state is called a *convention.* In our game, (*l, H*) and (*h, L*) are the only conventions.

Young's (1998) Theorem 4.1 proves that our evolutionary game, as described so far, must converge to one of the conventions, and then lock in. Which convention, either (*l*, *H*) or (*h*, *L*), is converged on depends the beginning state and on which samples are drawn. Table 4 shows the play in xx periods of the game, in which the initial state (chosen randomly) is {(*l*, *L*), (*l*, *H*), (*h*, *L*), (*h*, *L*), (*h*, *H*)}. In period 2, each player draws a random sample of size 2 from the five previous periods of play. In this particular example, the farmer drew *H* twice, he assumed therefore that *H* would be played in period 2 with probability 1, and from Table 3, his best response was *l*. Similarly, the non-farmer drew *h* twice, and his best response was *L*. Thus, the joint strategy played in period 2 is (*l*, *L*). Continuing in this manner, the game converges by the twelfth period to the convention (*l*, *H*), with farmers making low political expenditures and non-farmers making high political expenditures forever thereafter. Had we started at a different initial state, the game could have converged to the convention (*h*, *L*). But Young's Theorem 4.1 proves that no matter the initial state, the errorless game must converge to one of these two conventions.

Table 4. A typical run in the errorless game.

Period	Strategy four periods previous	Strategy three periods previous	Strategy two periods previous	Strategy one period previous	Strategy in the current period
1	(*l*, *L*)	(*l*, *H*)	(*h*, *L*)	(*h*, *L*)	(*h*, *H*)
2	(*l*, *H*)	(*h*, *L*)	(*h*, *L*)	(*h*, *H*)	(*l*, *L*)
3	(*h*, *L*)	(*h*, *L*)	(*h*, *H*)	(*l*, *L*)	(*l*, *H*)
4	(*h*, *L*)	(*h*, *H*)	(*l*, *L*)	(*l*, *H*)	(*l*, *L*)
5	(*h*, *H*)	(*l*, *L*)	(*l*, *H*)	(*l*, *L*)	(*l*, *L*)
6	(*l*, *L*)	(*l*, *H*)	(*l*, *L*)	(*l*, *L*)	(*l*, *H*)
7	(*l*, *H*)	(*l*, *L*)	(*l*, *L*)	(*l*, *H*)	(*h*, *H*)
8	(*l*, *L*)	(*l*, *L*)	(*l*, *H*)	(*h*, *H*)	(*l*, *H*)
9	(*l*, *L*)	(*l*, *H*)	(*h*, *H*)	(*l*, *H*)	(*l*, *H*)
10	(*l*, *H*)	(*h*, *H*)	(*l*, *H*)	(*l*, *H*)	(*l*, *H*)
11	(*h*, *H*)	(*l*, *H*)	(*l*, *H*)	(*l*, *H*)	(*l*, *H*)
12	(*l*, *H*)	(*l*, *H*)	(*l*, *H*)	(*l*, *H*)	(*l*, *H*)
13	(*l*, *H*)	(*l*, *H*)	(*l*, *H*)	(*l*, *H*)	(*l*, *H*)
14	(*l*, *H*)	(*l*, *H*)	(*l*, *H*)	(*l*, *H*)	(*l*, *H*)

The game with errors

Evolutionary games achieve many interesting results when it is assumed that players might make mistakes. We will model such mistakes by assuming that for some small positive value ε, a player plays his best response with probability 1- ε, but otherwise plays the other response. This error structure implies that the players can sometimes "bounce out" of an absorbing state. If, for example, they are in state { (*l*, *H*), (*l*, *H*), (*l*, *H*), (*l*, *H*), (*l*, *H*) }, it is possible that both will make a mistake, and therefore the state in the following period will be { (*l*, *H*), (*l*, *H*), (*l*, *H*), (*l*, *H*), (*h*, *L*) }. Given certain samples or certain additional mistakes in the coming periods, the players could eventually even wind up at the state which when the error probability $\varepsilon = 0$ is an absorbing state, { (*h*, *L*), (*h*, *L*), (*h*, *L*), (*h*, *L*), (*h*, *L*) }. If the players did "bounce and choose" their way to this state, the smaller is ε, the more probable it is that they will stay at { (*l*, *H*), (*l*, *H*), (*l*, *H*), (*l*, *H*), (*l*, *H*) }, for many periods, since the probability of "bouncing" out of that state and staying out is small.

Young's Theorem 4.1 implies that in the game with errors, when the game is played many periods, the overwhelming majority of the states observed (i.e, the stochastically stable states) will be comprised of the risk-dominant convention. The risk dominant convention in our model is (*l, H*). Those, no matter if we started at the absorbing state{ (*h, L*), (*h, L*), (*h, L*), (*h, L*), (*h, L*) }, if the game is played long enough, eventually the players will make mistakes, bounce out of { (*h, L*), (*h, L*), (*h, L*), (*h, L*), (*h, L*) }, and wind up at { (*l, H*), (*l, H*), (*l, H*), (*l, H*), (*l, H*) } for the vast majority of periods played. For this reason, we might call (*l, H*) the normal convention in our model. That is, in "normal" circumstances, our model's political economic equilibrium sees farmers making low political expenditures, and non-farmers making high political expenditures.

The game with shocks

To model a socio-economic "shock," such as the Great Depression/World War II, we assume that for a number of periods the players of our game face a different payoff matrix, which is shown in Table 5.

Table 5. The basic game during shocked periods.

	Non-farmer plays high political expenditures, H	*Non-farmer plays low political expenditures, L*
Farmer plays low political expenditues, l	(2.9, 4.0)	(5.0, 3.0)
Farmer plays high political expenditures, h	(2.0, 1.1)	(6.0, 2.9)

We will use European and U.S. experiences during the Great Depression and World War II to tell the following story about Table 5. After the shock hits, for some reason non-farmers get less utility from making high political expenditures than they did before the shock. Perhaps farm income is hit harder by the shock than is non-farm income, and non-farmers start feeling altruistic and less willing to fight their poorer opponents politically (Becker, 1985, Bullock, 1994). Or perhaps for national security reasons, the public recognizes food as a more important product during the years of shock. Whatever the reason, non-farmers utility when they play *H* and farmers play *l* is only 4.0, a big drop from the 6.0 that this same strategy profile brought non-farmers during non-shock years. Similarly, even if farmers are making high political expenditures, non-farmers receive a payoff of only 1.1 if they also make high political expenditures—again a big drop from the payoff of 2.1 in the non-shock years. The Nash equilibrium strategy profiles during the shock years remain (*l, H*) and (*h, L*). However the risk dominant strategy profile is now (*h, L*) instead of (*l, H*). Thus, during the shock years, we expect the game to take a turn away from convention (*l, H*) and towards convention (*h, L*). This resembles the sort of political change witnessed in Europe and the U.S. during the Great Depression—political calls from farm groups in support of public subsidization of agriculture rose, and it was met with only low levels of political resistance from non-farm groups.

Another interesting characteristic of our model is that after the shock years are over, the shock-year convention (*h, L*) can stay in place for many periods. Mathematically, this happens because the players have limited rationality in our model—they remember only five periods, sample only two, and develop their expectations about their opponents' play based on such samples. Thus, this political economy is characterized by inertia. People tend to think that their opponents will play what they played recently. With both groups thinking this way, joint strategy profiles that were risk-dominant during shock years can prevail for several years after the shocks have passed. This is illustrated in

Figure 3, which illustrates the results of simulating our model for 100 periods, with a 1% rate of error, starting from a randomly chosen state. (The computer program was written in *Mathematica*.) Figure 3 shows the political economy soon settled into convention (*l*, *H*), bouncing away from it from time to time as the players made errors. In period 46, the "shock" hits. After a few years, the political economy is driven to the (*h*, *L*) convention. The shock periods in this simulation are periods 46-60. Note, however, that the economy is at the (*l*, *H*) convention regularly during periods 51-83. The political economy has inertia; players tend to assume that what their opponents have done in the past will be what they are likely to do in the future. In a nutshell, Depression-era policies last far longer than the Depression itself.

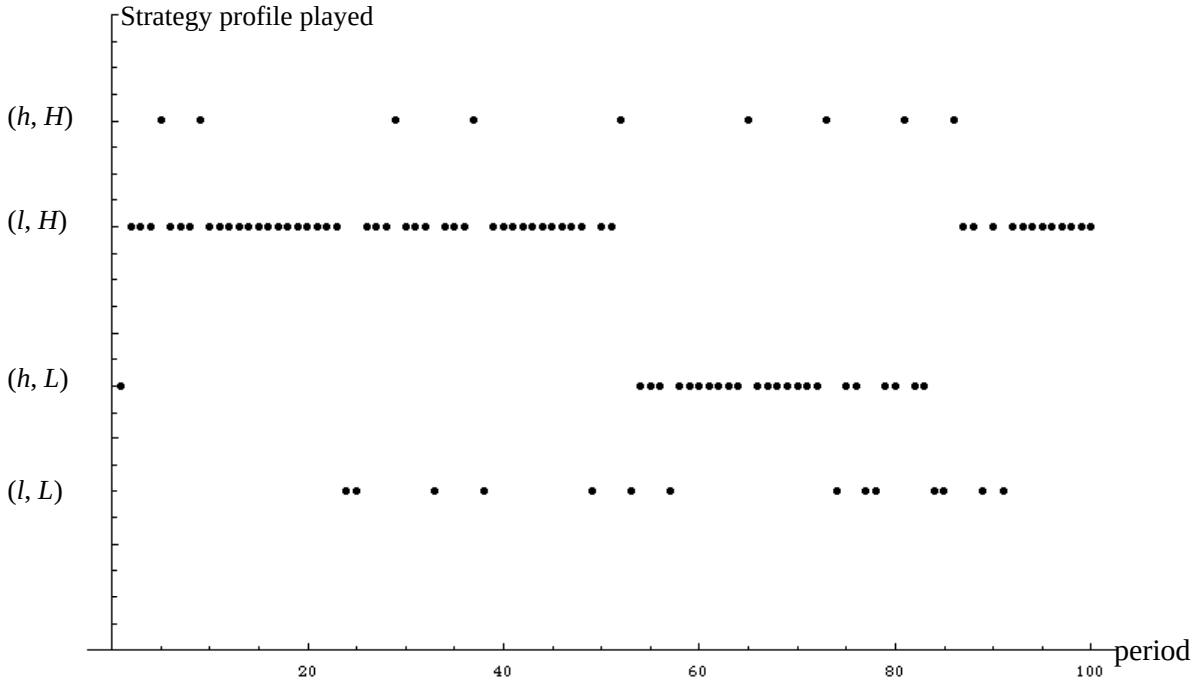

Figure 3. Strategy profiles when periods 46-60 are shocked.

Conclusions

A review of the history of agricultural political economy in Europe and the U.S. reveals that socio-political "shocks" have led many times to agricultural policy changes, and even to changes in the institutions through which agricultural policy is conducted. Moreover, agricultural policy institutions seem to be substantially inert—once an institution is in place, it has a life of its own. The political process does not remove it easily. We have modelled the effects of shocks and institutional inertia using evolutionary game theory. Our model has led us to propose that European and U.S. agricultural policy may not be currently in "normal" equilibrium, but rather that the current political economic equilibrium, in which farmers make large political expenditures and are met with little political resistance by non-farmers, results from institutional inertia from Depression and post-World War II policy changes.

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