Discussion Paper No. 474

Peasants, Potatoes, and Poverty: Transactions Costs in Prefamine Ireland

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April 1981

Preliminary version, not for quotation. The comments and help of Letty Anderson, Brian Binger, and Aba Schwartz are acknowledged.

INTRODUCTION

Before the ecological warnings of such writers as Rachel Carson and Barry Commoner became popular, productivity growth was generally considered to be desirable. After all, if a new technique is not "better", it will not be adopted. Economic historians concerned themselves less with the welfare effects of technological change than with the search for the reason why an innovation was adopted, or why it was not adopted in spite of its apparent superiority. The question by how much an innovation increased welfare was more important than whether it did so at all. Among Marxist economic historians the reverse seems often the case: they too seldom asked whether technological progress improved welfare but took the negative answer for granted.

The present paper derives its inspiration from a cryptic but thought-provoking passage which William Parker wrote in 1969. Parker remarked that {1}

> "...the word 'productivity' pushes a historian toward economics, but the term 'productivity growth' pushes an economist toward history. The economist who uses it must ask himself, how over history can productivity change"?

We would only add to that that the economist also may want to ask the historian whether it is really self-evident that productivity growth is necessarily beneficial.

The great danger in productivity measurement is always that some apparent gains in productivity may be the result of "unaccounted" inputs. If these inputs are scarce but for some

reason not paid for, the gains in productivity could be in part imaginary and indeed could ultimately plunge the system into a regime of lower productivity. Examples of such temporary gains are by no means novel {2}. In this paper we propose an example of a case of apparent technological improvement which had serious externalities for the rest of the economy, and which ultimately may have led the entire economy into unprecedented disaster. The innovation we have in mind is the introduction of the potato as a staple food in Ireland in the seventeenth and eighteenth centuries.

IRISH POTATOES: A BRIEF SURVEY

In the first half of the nineteenth century, Ireland was utterly dependent on potatoes. In 1845, on the eve of the Great Famine, about 2.1 million acres were planted with potatoes. This area amounts to one seventh of total land under cultivation and about a third of land under tillage. At some reasonable assumptions concerning per acre output and the proportions of the crop directly consumed by humans, the per capita consumption of potatoes in Ireland before the Famine was five to six lbs. per capita per day, providing around 1750 calories per person per day. These estimates imply that the vast majority of the Irish depended almost exclusively on potatoes, and that even for the urban and better-off classes potatoes were the mainstay of the Irish diet. For the sake of comparison, in East-Elbian Prussia, where potatoes were also playing a crucial role in the economy, only 4.3 percent of the arable land was planted with potatoes {3}.

The literature on Irish agricultural history has traditionally emphasized two aspects of the impact of the potato on Ireland. One of these is the obvious and enormous effect of the potato on agricultural productivity, where the output is measured in terms of nutritional value rather than money. The wondrous properties of the potato were well-known to all contemporaries. Potatoes can be grown in almost any soil conditions, including steep mountain soils not otherwise useable for field crops. The output of an acre of potatoes in terms of calories is between 2 and 3.5 times that of cereals. Potatoes

contain proteins as well as a wealth of other nutrients such as iron, niacin, vitamin C, and thiamin.

Little wonder, then, that this "gift, humble and unobtrusive" as one historian has called it in an irresistible phrase, revolutionized Irish agriculture to an extent at least comparable to the effect of the enclosures on British agriculture. Indeed, it seems that what has to be explained is the slowness with which other regions in Europe overcame their reluctance to adopt potatoes. The great spurt in potato cultivation in Eastern Europe did not come until 1770 (and in some regions considerably later still). In 1770 the potato was clearly the main staple in Ireland, although it may not yet have been as indispensable as it became in the 1830s and 1840s. At first sight, then, the potato seems a classic case of productivity growth. It seems reasonable to conclude that potatoes were a superior crop at any set of factor prices, although it is hard to demonstrate that unequivocally {4}. The potato increased both the quantity and the quality of the food supply, and in the process allowed more land to be brought into cultivation, or shifted from pasturage to tillage. Moreover, until the onslaught of the blight in 1845, major crop failures in Ireland were rare.

A second effect of the potato on Ireland, widely discussed in the literature, is the alleged effect it had on population growth. In this view, the potato allowed the Irish to marry younger and relax all constraints on fertility. The marginal cost of feeding a family was very low if the individuals were

willing to subsist on a diet consisting exclusively of potatoes. One and a half acres of potatoes could provide food for a family of six {5}. According to this interpretation, which maintains that the potato was an exogenous source of productivity growth and led to a Malthusian response, the short-run positive effects of the potato were offset by long-run population growth {6}. If this view is accepted, it follows that the introduction of the potato was at best a mixed blessing for Ireland, since its adoption allowed population to grow under the false assumption that this rich and cheap source of food was secure for ever. The blight and the disillusionment with the potato are seen as forcing the Irish economy to contract severely after 1845, a process accompanied by immense human suffering. The implications for this view as far as the analysis of productivity are concerned are that the measured gains in average output were bought at the price of a significant increase in variance of output, although the increased riskiness did not reveal itself until disaster struck. A comparable 'false' gain in productivity would be observed for example if a town were built in an earthquake-prone region otherwise well-suited for urban location.

In this paper we intend to examine the possibility that the potato may have led to poverty and economic backwardness despite an initial appearance that it was a more efficient way of producing food. Ireland before the Famine was already one of the most backward regions in Europe. Accounts of contemporaries are unanimous on this issue. Quantitative measures, conjectural as they are, confirm the backwardness of Ireland in many aspects.

At the same time, as we have seen, Ireland was firmly committed to the potato. Were these two phenomena related?{7} At first glance it seems far-fetched to blame the potato for Ireland's backwardness If anything, it would seem that Ireland was poor despite its dependency on the potato diet. While housing, clothing, household implements, education, transportation, and personal comforts were all highly deficient in both quantity and quality, the Irish were comparatively well provided for from a nutritional if not culinary point of view. It seems fairly safe to surmise that on the eve of the famine Ireland was one of the best fed nations in Europe.

To understand how the potato might have contributed to Ireland's backwardness, consider the restrictions which the potato imposed on the Irish economy. In the nineteenth century the potato was characterized by particularly high costs of storage, marketing, and distribution. No varieties could be stored for longer than ten months. Marketing and distribution problems stemmed from the high water content of potatoes: 75 percent of the weight is water. Consequently transport costs were high relative to market value. Moreover, in early nineteenth century Ireland, potatoes were subject to severe spoilage when transported by primitive vehicles on bumpy country roads. Although potatoes were bought and sold in both urban and rural markets, high costs of transacting and transporting them dictated that wherever the potato was grown, the bulk of the crop was consumed either by the same people who produced it or by their immediate neighbors {8}.

Adoption of the potato as a subsistence crop in Ireland meant that the potato came to play a role comparable to that of the turnip in the light-soil agriculture in Britain. In Ireland the potato was grown for food, cash crops for rent and other consumer goods. Like turnips, potatoes were grown in rotation with grains {9}. The difficulty was that once a rotation system like this was firmly entrenched, it became difficult to change it. Grain crops required soil preparation, so farmers who might have wished to experiment with other foods, had to continue to grow potatoes or overhaul the entire set-up of agricultural production {10}. On the other hand, potatoes required the cash crop not only for purposes of crop rotation, but mainly because rents (and thus money) were a necessary input in the growing of potatoes. Thus, had the potato been widely marketed, a peasant could have displayed considerably more flexibility in his decision making process by allowing him to either raise the necessary cash by selling potatoes, or to experiment with other crops and buy his food. The particular situation in Ireland tended to lock peasants increasingly into both potato production and potato subsistence. This "lock-in" led not only to a technologically stagnant peasantry, but also to considerable resistance by the tenants to proposed changes by landlords or large farmers {11}.

In this paper, we shall discuss the social cost which the potato inflicted on the Irish economy on three levels. First, we shall show that the gains in total food output resulting from the adoption of the potato were bought at the price of considerable increases in vulnerability and risk. It was

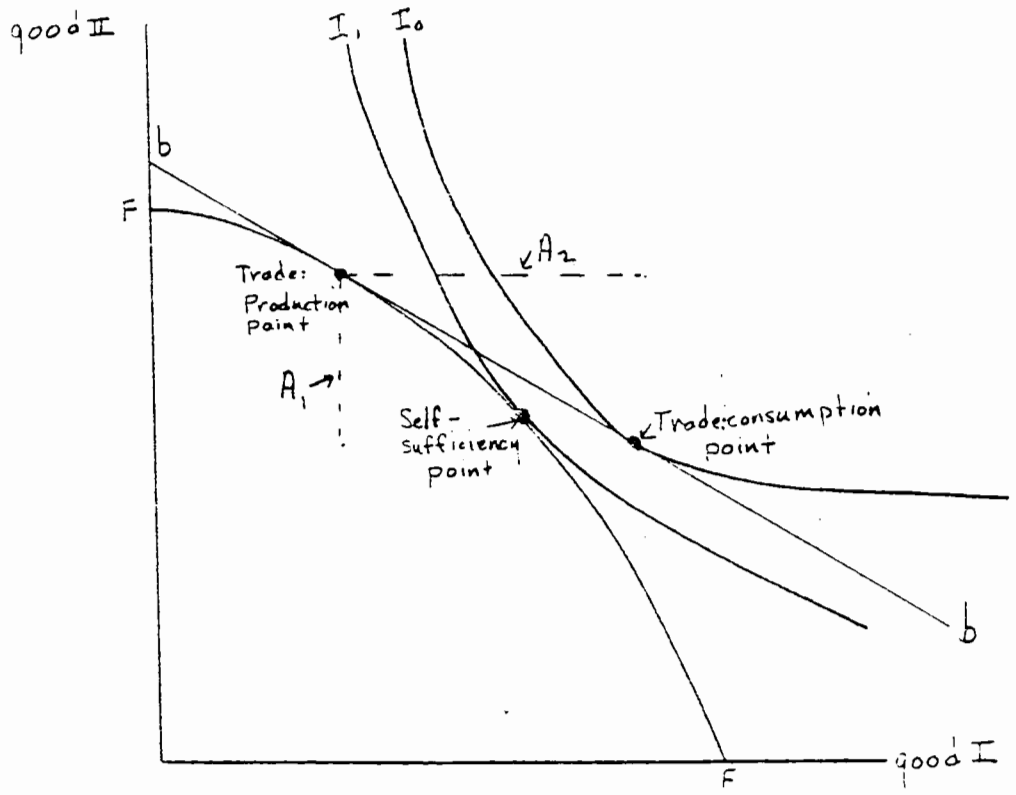
difficult for the Irish peasants to recognize their "error" and even more difficult to reverse the course they had chosen. Thus they were left open to increasing uncertainty and ultimately to disaster. Second, we shall discuss how the de-commercialization of Ireland was likely to have caused serious negative externalities for the economy as a whole. Third, we shall indicate how certain exogenous "shocks" imposed on the Irish economy before the Famine were likely to have reinforced the de-commercialization of the rural economy.

In the next section we shall construct the theoretical framework in which these issues can be analyzed in some detail. We return to the prefamine economy in the following section, in which the relevance of the models will be demonstrated. The concluding section contains an attempt to utilize cross-sectional aggregate data to test the hypothesis that potatoes affected the level of income in the prefamine economy.

SOME MODELS OF THE POTATO ECONOMY

The model we present below formalizes some of the constraints which the potato imposed on an economy dependent on it and explores some of the ways in which it could lead ultimately to impoverishment. The model is "neoclassical" in that it assumes that peasants do not waste resources in a systematic way. In other words, in the long run the economy will drift toward an efficient allocation of resources, subject to the various constraints on its operation. It is on these constraints that we wish to concentrate.

It is best to start with the simple model of a peasant economy. At least since Adam Smith economists have known that there are two distinct sources of increased productivity and welfare. One source is an outward shift of the product possibility frontier due to technological progress (including new crops). The other source is through exchange. The demonstration that exchange between different economic agents (or economies) can lead to increased welfare for all without any shift in the product possibility frontier is one of the most triumphant moments in any course in price theory or international trade and a fundamental justification of free enterprise economics.



Welfare Gains from Market Production

figure 1

For the economic historian concerned with the agricultural societies of premodern Europe, the simple production and exchange model of fig. 1 is interesting but basically not much more than a foundation on which to build further. From the point of view of the description of the individual peasant or peasant community, it abstracts from a crucial element, namely risk. Risk, defined as undesired variation in consumption, can be reduced in three ways. First, it can be reduced by diversifying the portfolio of lots cultivated and crops grown. Second, risk can be reduced by trading. Third, variation can be reduced by storage of buffer stocks. A combination of the latter two is

ling inventories of money, buying and selling in years of city and plenty respectively.

To isolate how trade can provide a means of reducing risk, ıe that peasants produce only one crop and that all land is enous. Assume further that all trade is barter, and that are perfectly perishable. It is still true that the ıts can reduce the variance in consumption if the goods they produce are not the goods they consume, and the ge takes place in a market context. For simplicity suppose ıe peasants do not desire the good they produce at all and ge it at the market for something which we may call ". The intuitive explanation of the risk-reducing effects erce is simply that the demand curve facing the community tion serves as a cushion absorbing stochastic shocks in ... output. In years in which physical output is small, prices are high and vice versa.

Formally, let physical output in year i be Xi. For the self-sufficient peasant who does not trade or store

(1) $Y_i \equiv X_i$ for each peasant

so that VAR(Y) = VAR(X), that is, the variance in consumptio equals the variance in production. Now suppose that there i trade but no storage. Then for each year:

(2) $Y_i = P_i X_i$

Let the demand curve facing the unit under discussion be of th fixed elasticity variety:

$$X = BP^{-\beta} \qquad \beta > 0 \tag{3}$$

so that

$$P = AX^{-1/\beta} \qquad A = B^{1/\beta} \tag{4}$$

so that:

$$Y = AX^{(1-\frac{1}{\beta})} \tag{5}$$

The methodology employed is to compare the variance of the logarithm of Y with the variance of the logarithm of X {12}. To the extent that trade can make the former smaller than the latter, it is true that trade reduces the variance in consumption. We are assuming for simplicity that the consumer would prefer to consume the same quantities in each year i, so that <u>any</u> variance is undesirable. Taking logarithms on both sides of eq. (5):

$$\log(Y) = \log(A) + (1-1/\beta)\log(X) \tag{6}$$

$$\mathrm{Var}\{\log(Y)\} = \mathrm{Var}\{\log(A)\} + (1-1/\beta)^2 \cdot \mathrm{Var}\{\log(X)\} + 2(1-1/\beta)\mathrm{Cov}\{\log(A),\log(X)\} \tag{7}$$

If the demand curve is stable, the first and last terms on the right hand side of (7) drop out, and the condition for trade to be risk-reducing is:

$$(1-1/\beta)^2 < 1 \text{ , or:} \tag{8}$$

$$\beta > 1/2. \tag{9}$$

Actually, the relation between the elasticity of demand β and

risk reduction is non-monotonic. For $\beta = 1$, eq. (7) implies that variance is zero. Clearly, unitary elasticity of demand implies constant revenue. For $\beta \to 0$ and for $\beta = 1/2$, there is no gain in trading as far as risk-reduction is concerned, and for $\beta < 1/2$, the risk is actually increased. For the single individual, it is likely that β is quite large and possibly infinite. However, the smaller the unit under consideration, the larger the elasticity of demand it faces, but the higher is the likelihood that A and X are correlated. For instance, a case of harvest failure (low X) is likely to be associated with harvest failure among other units, which will result in a rise in A (demand curve facing the unit shifts up). Thus, $Cov\{\log(A),\log(X)\}$ is negative. For $\beta > 1$, this means that the market can absorb some of the fluctuations in X. If the demand curve is unstable, so that A is subject to annual variations, eq. (8) can be generalized to:

$$(10)\quad [\gamma+(1-\beta)]^2 < 1-\frac{\text{var}(\log e)}{\text{var}(\log X)}$$

where γ is the partial regression coefficient of $\log(A)$ with respect to $\log(X)$, and e is the random factor affecting A but not X. Comparing eqs. (8) and (10) we can see that if γ is negative (as seems reasonable to suppose) and sufficiently large in absolute value, it would increase the risk-reducing effect of trade. On the other hand, if the variance of the random component is very large relative to the variance of X, the risk-reducing effects of trade are reduced. In any event there

is no justification for assertions which maintain that "the cash crop is in fact the risky choice for a subsistence farmer....A farmer who buys his food must consider the yield variance of the cash crop as well as the price variance ... for the farmer who grows and consumes his own crop, only the yield variance is relevant" {13}.

Note that this model is a partial equilibrium model. Fluctuations occur not only in the output of the goods that the peasant sells, but also in the production of the goods he buys. Supply shocks in the price of consumption goods take the form of stochastic movements of A, which possibly could offset the "gains from trade" as far as risk is concerned.

The economy as a whole obviously cannot gain from trade without storage, since the variance in aggregate output is not reduced by internal trade. Each subset of the economy can, however, achieve a real reduction in consumption variance due to trade. When transportation or similar costs make trade expensive and rare, this opportunity is lost.

In the more general case, which includes the autarktic and fully commercialized peasant as special cases, output is divided between spot consumption and the market:

$$\{11\} \qquad Y = qX + (1-q)(PX),\ 0 \leq q \leq 1$$

It is clear that q is a positive function of the level of transactions costs. If these costs are very low or zero, q could equal zero. If they are sufficiently high to dominate the gains from trade, q may tend to unity. In the mathematical appendix,

available upon request from the authors, we prove the following proposition:

Proposition : If the elasticity of demand facing the "unit" under consideration is equal to or larger than one, an increase in q will increase the variance of Y. If the demand curve is inelastic, an increase in q will increase the variance of Y as long as $q > 1-\beta$ and decrease it if $q < 1-\beta$. Strictly speaking, the proposition is true only for sufficiently large values of β, about .5 or larger.

When storage is introduced, the variance of consumption is reduced simply by means of buffer stocks. If storage costs (including interest) are zero, there is no reason why the actual consumption pattern should not be equal to the desired pattern - possibly reducing variance to zero. With storage, the role of trade as an activity which reduces the variance of consumption is altered. If there are no storage costs, obviously storage alone will be used to reduce variance, but if there are storage costs, it is likely that the peasant will find it cheaper to store money than commodities for a rainy day.

We will now present a formal demonstration that under certain general conditions transactions costs and storage costs tend to increase the variance of output.

Suppose a peasant produces a good, X, which is distributed as a random variable which can assume only 2 possible values, a high value X^H and a low value X^L. After each observation of the random variable (i.e., at the end of each crop year) the peasant decides how much of his crop to consume and how much to store or

market. If he can store but not trade, he has to decide how much net storage, S_t, to carry forward. If he can trade and store money (but not store the output), a decision to market is equivalent to a decision to carry forward some net money income. Since we may assume that the least expensive method of providing buffer stocks will be chosen, we will consider only these two cases.

Let:

S_t^L, S_t^H = storage in period t, given $X = X^L, X^H$, respectively

C_s = storage cost per unit stored

M_t^L, M_t^H = amount of X marketed in period t, given $X = X^L, X^H$, respectively.

C_M = marketing cost per unit marketed.

Y_t = net money stored in period t.

Q_t^S = consumption in period t after storage decision.

Q_t^M = consumption in period t after marketing decision.

$U_t(Q^S_t), U_t(Q_t^M)$ = peasants' utility functions over consumption with storage and marketing respectively.

Assume that the U functions obey the standard conditions.

S_t^*, M_t^* = optimal values of S_t and M_t respectively.

Since each decision the peasant makes has implications for future consumption, the optimization problem assumes all future decisions will also be optimal. Thus, given an initial stock of storage and money at time t, the dynamic programming problem has the following form:

$$\text{Storage: } \max_{S_t} V_t^S = EU_t(X, S_t) + V_{t-1}^S(S_t^*, C_s)$$

Trade: $\max_{M_t} V_t^M = EU_t(X,M_t) + V_{t-1}^M (M_t^*, C_M)$, where

V_t^S, V_t^M = valuation function at time t under storage and trade respectively. Note that t is earlier in time than t-1 because of the backward induction method of dynamic programming.

The definitions imply that:

$$EQ_t^S = E[(1-C_s)S_{t+1} + X - S_t] \text{ and}$$

$$EY_{t-1} = Y_t + EM_t. \text{ Therefore,}$$

$$EQ_t^M = E[Y_{t+1} + X - Y_t(Y_{t+1}, M_t) - C_M M_t].$$

Thus, the peasant's problems in period t are:

Storage: $\max_{S_t} V_t^S = EU_t[(1-C_s)S_{t+1} + X - S_t] + V_{t-1}^S \{EU_{t-1}[(1-C_s)S_t^* + X - S_{t-1}] + V_{t-2}^S\}$

Trade: $\max_{M_t} V_t^M = EU_t[Y_{t+1} + X - Y_t(Y_{t+1}, M_t) - C_M M_t] +$

$$V_{t-1}^M \{EU_{t-1}[Y_t(Y_{t+1}, M_t^*) + X - Y_{t-1}(Y_t, M_{t-1}) -$$

$$C_M M_{t-1}] + V_{t-2}^M\}$$

We can now state the following theorems, which we prove in the mathematical appendix to this paper.

T.1: An optimal storage or marketing policy needs to consider only the effect of current storage or marketing on current consumption and next period consumption. This follows from the envelope theorem.

T.2: An increase in the cost of storage or marketing reduces storage or marketing through a substitution effect, but increases storage or marketing through a next period income effect (i.e., lower storage or marketing reduces potential consumption next period).

T.3: $\frac{dS_t^*}{dC_s} < 0$ and $\frac{dM_t^*}{dC_M} < 0$ if the substitution effect

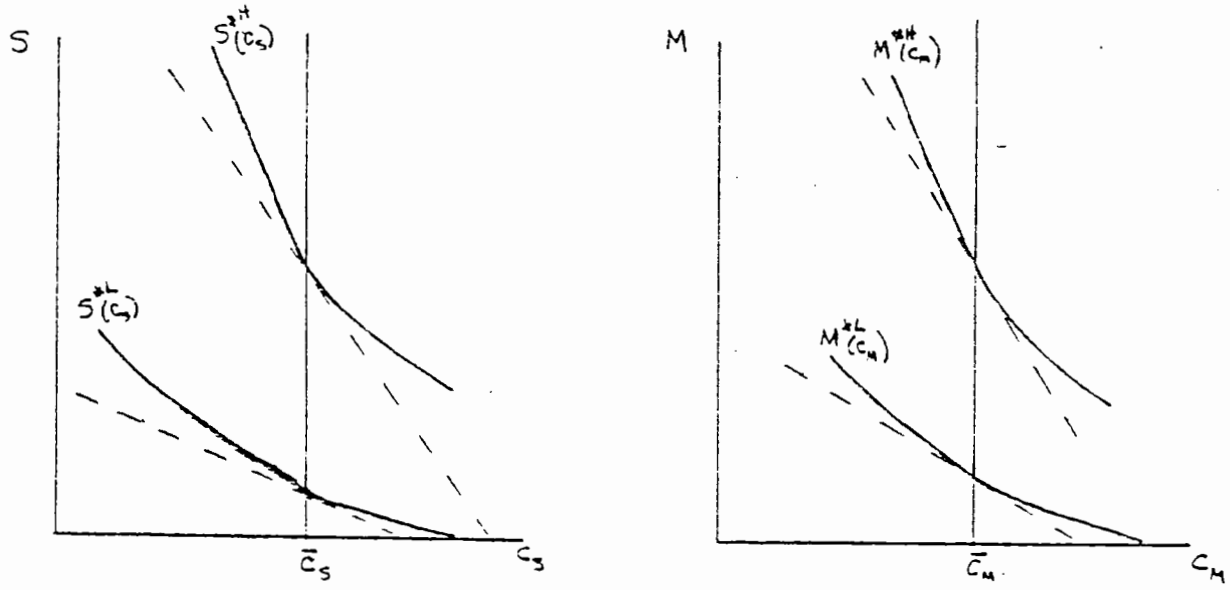
outweighs the income effect. This follows from T.2.

T.4: If $\frac{dS_t^*}{dC_s} < 0$, $\frac{dM_t^*}{dC_M} < 0$, and $Q_t^H > Q_t^L$ always, then

$$\frac{d[\mathrm{Var}(Q_t^S)]}{dC_s} > 0 \text{ and } \frac{d[\mathrm{Var}(Q_t^M)]}{dC_M} > 0 \text{ if } \frac{dS_t^{*L}}{dC_s} - \frac{dS_t^{*H}}{dC_s} > 0$$

$$\text{and } \frac{dM_t^{*L}}{dC_M} - \frac{dM_t^{*H}}{dC_M} > 0, \text{ respectively}$$

To see the intuition behind T.4, consider fig. 2 below.



Optimal Storage and Marketing as a Function of Costs

fig. 2

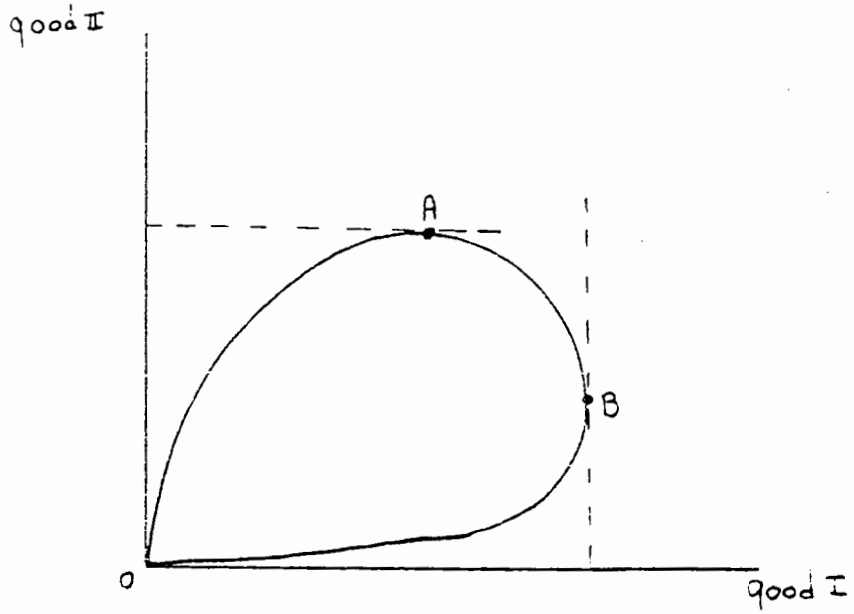
The conditions $\frac{dS_t^{*L}}{dC_S} - \frac{dS_t^{*H}}{dC_S} > 0$ and $\frac{dM_t^{*L}}{dC_M} - \frac{dM_t^{*H}}{dC_M} > 0$ imply that the storage and marketing functions must be less steeply sloped at each vertical line when X is low than when X is high. Intuitively it can be seen that, given C, buffer stocks and amounts marketed are going to zero at a slower rate when X is low. In other words, when X is high, the peasant can afford to reduce next period's buffer stocks faster in response to price changes than when X is low. This income effect occurs because the expected value of next period's consumption is higher when X is higher.

We conjecture that T.4 generalizes to the case of

multivalued discrete random variables as long as the storage or marketing function is less steeply sloped when $X < E(X)$ than when $X > E(X)$.

We now leave the world in which potatoes are the only good produced, and examine the effect of transactions costs of potatoes on other crops (which are assumed to be free of them). Of particular interest is the effect of a change in the terms of trade between the two types of crop.

In the simplest models, it is assumed that the two goods compete for the same factors of production but otherwise are produced independently of each other. This assumption is patently unrealistic in agricultural societies. Even before root crops were widely cultivated, "joint production" was universal. Livestock and cereals ("bêtes et blé") were unthinkable without each other: animals pulled ploughs and harrows and provided manure. Animals ate oats and straw and grazed on crop land after harvest. In the new husbandry and in Ireland, root crops and cereals were jointly produced in a crop cycle. It can be shown without much difficulty that if the two products are necessary inputs into each other (i.e., the production function is non-separable), the product possibility frontier will be balloon-shaped as in fig. 3. Only the segment between points A and B is relevant to our peasant, however, since on the upward segments of the frontier more of both goods can be produced by reshuffling the resources.

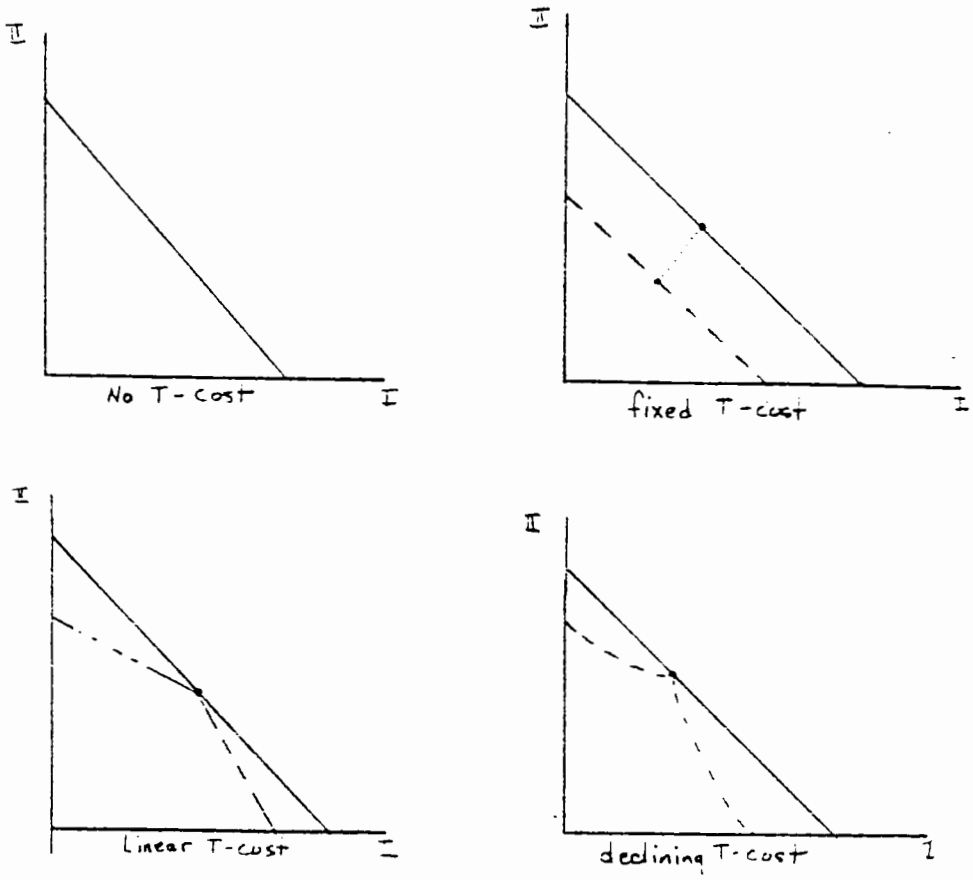


Joint Product Possibility Frontier

fig. 3

The simple model of fig. 1 is further complicated by the existence of transactions costs. By that term we designate any cost which is incurred in selling A1 or buying A2. Transaction costs change the location and shape of the line bb facing the individual trader. The exact nature of the effect depends on the form of the transactions costs function. For instance, if the nature of transactions costs is mostly information costs, the cost function could be dominated by fixed costs. Fixed costs reduce the number of traders, but do not affect marginal decisions. If transportation costs are dominant, there will in all likelihood be both a fixed and a variable component. Some

examples of the effect of different transactions costs functions on the price line bb are presented in fig. 4.



Transactions Costs

fig. 4

Regardless of the form of the transactions costs, their existence implies in general a discontinuity in the choices made. In the simple world of fig. 1, there is a possibility of autarky only if by fluke the consumption point and the production point coincide. Any kind of transactions costs will result in a region of autarky in which there are gains from trade, but the gains are outweighed by the costs. Once the gains from trade exceed the costs, there is likely to be a discontinuous "leap" from autarky to substantial levels of trade.

Diagrammatic presentation runs into the dilemma that the Irish economy was never wholly autarktic. Even the poorest tenants had to sell some part of their output in order to acquire a minimum level of cash. This cash was then used to pay rents and tithes and purchase some goods which could not be produced on the farm. A large number of smallholders and cottiers thus found themselves self sufficient in food and fuel, but still having to sell some output on the market. Four "cash" goods were of importance in this respect: butter, pigs, grain crops, and non-agricultural goods produced in domestic industry. These cash crops were exchanged for other commodities (tobacco, drink, religious services, salt) or paid in rent. In addition there were the "subsistence" crops, potatoes and peat {14}. We assume that the "subsistence" goods are subject to transactions costs whereas the "cash" goods are not. With these "stylized facts" in mind, we can proceed with the construction of our model.

We assume an economy of peasants which produces two composite goods: a cash crop and a subsistence crop. The cash crop is grown exclusively for sale on the world market and the proceeds are used to purchase other goods. The subsistence crop may be bought or sold in the market or used exclusively for subsistence. The two goods differ in two important ways. First, the subsistence crop, if sold, implies a "marketing" cost paid by the seller {15}. Second, the cash crop has no use value for the producer, but this is irrelevant because it can be costlessly converted into other goods or inputs which do. The two production functions are interdependent so that each crop is

a necessary input into the other's production.

Definitions:

L_i = labor supplied by peasant i

A_i = land area farmed by peasant i

$P_i = g(L_i, A_i, V_i)$ = the quantity of the subsistence crop (e.g. potatoes) produced by peasant i

$B_i = f(L_i, A_i, P_i)$ = the quantity of the cash crop (e.g. grain) produced by peasant i

P_i^m = quantity of the subsistence crop sold by peasant i in the market

P_i^b = quantity of the subsistence crop bought by i in the market

q = market price of the subsistence crop

π = market price of the cash crop

$Y_i = \pi V_i + q(P_i^m - P_i^b)$ = money income of peasant i

d_i = i's distance from the market

$C_i = C(P_i^m, d_i)$ = the marketing cost function

$P_i^c = P_i - P_i^m(1 + C_i) + P_i^b$ = the quantity of the subsistence crop consumed by i

$U_i = U_i(Y_i, P_i^c)$ = the utility function of peasant i

We now make the following assumptions:

A.1: L,A, and d are fixed for each i. This assumption allows us to focus on the joint products and variable features of the model. Dropping this assumption only complicates the mathematics without changing the results.

A.2: The production functions f and g are continuous and have the standard properties of differentiability and concavity.

A.3: The transactions cost function C is concave, i.e. $\frac{\partial C_i}{\partial P_i^m} > 0$ and $\frac{\partial^2 C_i}{\partial (P_i^m)^2} < 0$. This assumption reflects the existence of economies of scale in transportation.

A.4: The peasant's utility function has the standard mathematical properties.

A.5: Cash and subsistence crops are gross complements in consumption, i.e., $\frac{\partial^2 U_i}{\partial Y_i \partial P_i^c} > 0$. This assumption means that having more of one good increases the marginal utility derived from the other.

A.6: The product possibility frontier can be written as

$$P_i = g_i(V_i) = g_i[f_i(P_i)] \text{ or } g_i^{-1} = V_i = f_i(P_i)$$

for each peasant, although the functions g and f are different from peasant to peasant, as allocations of land, labor and capital vary. This assumption implies that the transformation curve is balloon shaped so that $f'(0) > 0$ and $g'(0) > 0$ where g is the inverse of f.

A.7: The transformation function of the cash crop as a function of the subsistence crop is not so sharply convex to preclude marginal adjustments in production in response to changes in relative prices, i.e., $\left|\frac{\partial f_i / \partial P_i}{f_i}\right| \geq \left|\frac{\partial^2 f_i / \partial P_i^2}{\partial f_i / \partial P_i}\right|$

Dropping constants and i subscripts and substituting income, production, and transactions costs into the utility function, the maximization problem is as follows:

$$\max_{p, p^m, p^b} U\{[\pi f(P) + q(P^m - P^b)], [g(f(P)) - P^m - C(P^m) + P^b]\}$$

The following three properties of the model are immediate:

L.1: Given any ratio of prices, $g' < 0$ and $g'' < 0$, $f' < 0$ and $f'' < 0$ at a utility maximum. Thus, the peasant will only operate on the <u>downward sloping</u> segment of the product possibility curve.

L.2: No agent will be both a buyer and a seller of subsistence crops at the same time. This does not preclude, of course, a peasant to be a seller in one year and a buyer in another, if the parameters change over time.

L.3: An agent will buy the subsistence crop as long as $-qg' < \pi$, sell if $-qg' > \pi(1+C')$ and not participate in the market as long as $\pi < -qg' < \pi(1+C')$.

We now turn to the important properties of the model. Since the cash crop is traded at the world market, it's price is exogenously given to the peasant. Since changes in the terms of trade in the cash sector reflect many of the shocks to which Ireland was subject in the prefamine years, it is interesting to examine the effects of these shocks on the subsistence sector. In the mathematical appendix to this paper, the following properties are proven:

T.1: Buyers of the subsistence crop have downward sloping demand curves.

T.2: Sellers of the subsistence crop have upward sloping supply curve as long as they derive most of their income from the cash crop, i.e., as long as $\pi f \geq qp^m$

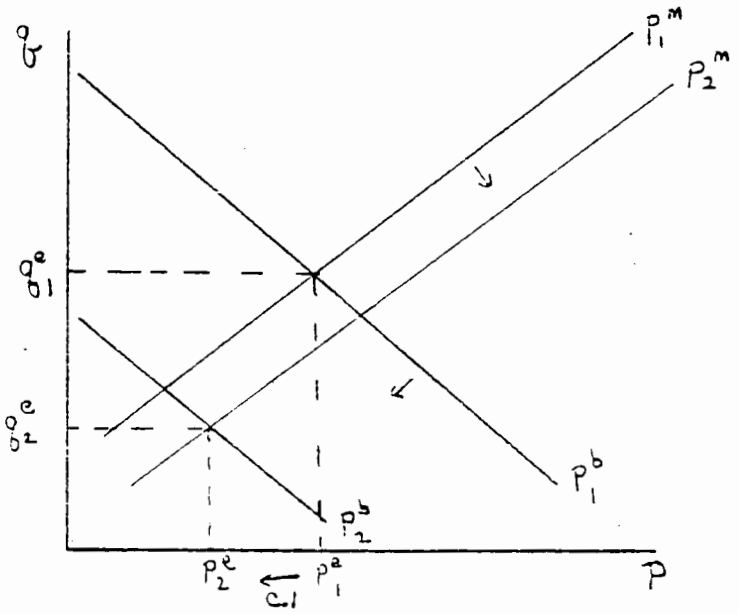
T.3: A decline in the price of the cash crop causes both buyers and sellers of the subsistence crop to produce more of it. The converse holds too. In other words, in a partial equilibrium setting, a decline (rise) in the price of the cash crop increases (decreases) the supply curve and reduces (increases) the demand curve of the subsistence crop.

T.4: (Follows immediately from T.3): A decline (rise) in the price of the cash crop causes a fall (rise) in the equilibrium

market price of the subsistence crop.

We have a final conjecture which we have not yet been able to prove:

C.1: A decline (rise) in the market price of the cash crop will cause a decline (rise) in the quantity of the subsistence crop transacted. The implications of these predictions are presented in fig. 5.



Effect of a Fall in the Price of the Cash Crop
on the Market Equilibrium for the Subsistence Crop

fig. 5

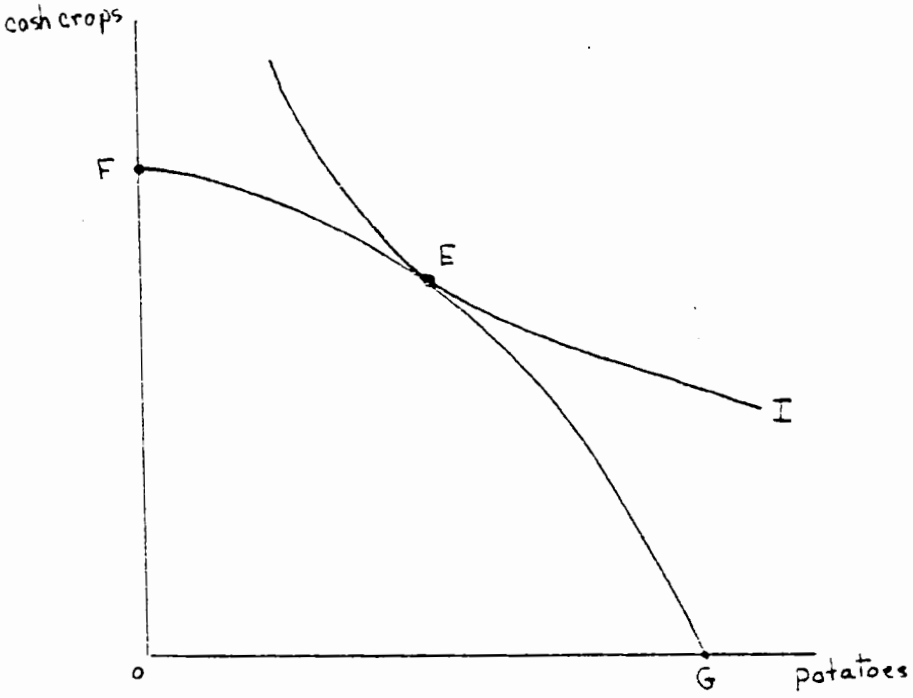
The price of the subsistence crop can be seen to decline unequivocally with a decline in the price of the cash crop. (Note : in the diagram, P, the horizontal axis, measures quantities of potatoes and the vertical axis, q, measures the price of potatoes) . The supply curve reflects both a decline in the quantity sold by individual sellers as the price falls and the fact that marginal sellers will tend to retire from the market. However, at the same time the demand curve reflects the fact that former buyers buy more and some marginal buyers enter the market, so that it is not intuitively obvious that a net reduction in the quantity transacted occurs. What makes the

problem mathematically difficult is that the marginal sellers who retire do not become buyers but are likely to become self-sufficient. Similarly, the new buyers do not come from the ranks of sellers but were probably self-sufficient before. Consequently, we have not been able to describe the second derivatives of the aggregate demand and supply functions. Our model predicts that anyone who changes, switches from cash-crop production to subsistence crops. If our conjecture is correct we should expect a "decommercialization" of the subsistence sector, and the entire economy becomes less market oriented, a rather unique experience in Europe in the first half of the nineteenth century.

We can now see the rather subtle sense in which the potato was a mixed blessing to the economies which adopted it. If it is true that it induced a reduction in market orientation and specialization in Ireland at a time when increased market specialization was one of the chief dynamic elements in the development of Europe, some of the mystery of Ireland's amazing backwardness is removed. Moreover, as we will show below, the two characteristics of the potato widely lamented by contemporaries, lack of portability (i.e., transactions costs as defined here) and lack of long-term storability implied a slightly different but equally pernicious influence of the potato.

There is another way in which potatoes could have been a liability to the Irish economy in the prefamine years in spite of their apparent superior efficiency as a means of extracting

food from the earth. {16} In order to illustrate this mechanism, we make a few simplifying assumptions. First, assume that there are two groups of individuals in the economy, landlords and peasants. The peasants consume both potatoes and "other goods" or "money income", whereas the landlords are interested in money income only, and do not consume potatoes. To stress the issue at hand, make the extreme assumption that the costs are such that potatoes are not traded at all, and have to be produced on the spot to be consumed, while there are no transactions costs associated with the cash crop. From the point of view of the landlord, this means that he will always want to produce cash crops since the market price of potatoes is zero. However, the peasant maximizes utility, not income, and will prefer an interior solution. Transactions costs drives a "wedge" between potatoes and income, and a conflict of interest thus emerges between landlord and peasant. The conflict is illustrated in fig. 6.



One Source of the Irish Land War

fig. 6

The product possibility frontier is denoted by the line FG. With an effective zero price for potatoes, landlords clearly wish to be at F, where income is maximized. Peasants will prefer to be at E where their utility is maximized. The striking feature of this model is that no side-payments can be arranged so that landlords and tenants can negotiate themselves into the core of the economy. The landlords cannot bribe the peasants with money to agree to be at point F, since the peasants have only limited use for money which cannot buy potatoes. The peasants cannot afford to pay the higher money rent implied at point F since they are too busy producing potatoes for their own

consumption. A struggle is likely to emerge in this model, and of course we do know that prefamine Ireland was strife-ridden in an often desperate war between peasants and landlords. The important aspect of such conflicts for Irish economic development is that they had, as always, serious spillover effects for investment and entrepreneurship. It may appear that the conflicts between landlords and tenants were about the level of rents, but they really were more about the composition of agricultural output.

Needless to say, this model is heavily oversimplified. Peasants - to some extent - did consume oatmeal and in some regions, bread. It is important to realize that the adversary of the smallholder and the landless laborer in these clashes was not always the landlord or his agent, but often a large farmer or grazier, who let out small potato gardens for money or as payment for labor services. {17} The struggle for the "right" to grow potatoes is thus somewhat more complex than the model would indicate. Nonetheless, without realizing the special features of the potato, much of the violence which marred the Irish countryside in the decades before the great Famine is more difficult to understand.

Some Evidence

By far the best and most detailed evidence on the cost of the potato in terms of portability and storability is contained in appendix E of the massive Poor Law Commission Report {18}. The "baronial examinations" dealing with food provide detailed comments on the effects of potatoes on local conditions,

comparing potatoes and grains in a variety of aspects. The baronial examinations were based on about a thousand witnesses from twenty counties. The witnesses unanimously pointed out the high transport costs of potatoes which greatly curtailed commerce in them. A Galway witness observed, for instance, that although potatoes were traded to some extent, a cart hauling 2.5 barrels of potatoes would feed an adult man for 120 days. The same cart could haul 20 cwts. of meal, which could feed an adult man for 640 days (PLR, XXXII, p. 4). "The large amount of nourishment contained in a small space makes corn much easy and cheap of carriage than potatoes," noted another witness. A witness from Dublin maintained that potatoes were never carried over land for more than 20 miles (PLR, XXXII, p. 11). A Wicklow witness estimated that there was "no increase in price" which would permit the farmers to carry potatoes for more than 40 miles and that only on extraordinary occasions, scarcely worth the price of carriage (PLR, XXXII, p. 11).

It may be added that the natural disadvantages under which potatoes were traded were compounded by man-made obstacles. One such obstacle was tolls which were charged by some market towns on potatoes. Although this custom was not general, it could be serious. The town of Tralee (co. Kerry) charged 30% of the value of potatoes {19}. Secondly, the quantities of potatoes were measured in a bewildering myriad of inconsistent and incompatible weights and measures. Potatoes were sometimes sold by weight and sometimes by volume. Wakefield presents a table of weights and measures which indicates that, for example, in the city of Londonderry oats and potatoes were sold by the stone but

in the rural parts by the bushel {20}. To confound things further, "a measure of potatoes weighs more winter than in spring and summer." The barrel of potatoes was equal to 40 stones in Tyrone, 21 stones in Kilkenny, 25 stones in Meath, 28 stones 8 lbs. in Monaghan. Even when measured in terms of weight alone, consistency left much to be desired: in Clare a stone of potatoes was 16 lbs. in summer and 18 lbs. in the winter. An exasperated correspondent from co. Cork added the remark that the measures of potatoes "vary much in neighbouring parishes and require to be regulated in all the South and West of Ireland" {21}.

It is thus not surprising that the low tradeability of the main food crop led often to famine and abundance in adjacent regions. Although the term "famine" should not be mistaken for a situation that even remotely resembled the cataclysmic events of 1845-1850, local scarcities could be serious enough. A Leitrim witness noted that "there have been instances of the peasantry being in a state of starvation in one district, while in a neighbouring district potatoes have been abundant" (PLR, XXXII, pp. 4-5). Similar complaints come from other parts of Ireland, although one witness contended that the reason for such discrepancies was simply that "the people in the starved district had no money to pay for them" (PLR, XXXII, p. 19). A county Mayo witness points out, however, that "last Monday potatoes were selling at Ballina, a distance of 15 miles, at 2d. a stone and on the same day they could not be had here under 3d. ... although the road is excellent" (PLR, XXXII, p. 8).

Transportation cost data are fragmentary at best. A large collection of them can be found in Wakefield's Ireland . Wakefield collected information from over 50 correspondents from all over Ireland. The data pertain to 1811, a year of high prices, but since we are chiefly interested in the relative price of transportation, this is of no concern. The transportation costs were computed from the entries of the item "land carriage from you to Dublin per cwt." The (unweighted) provincial means are presented in Table 1. The most interesting variable is K, which is the cost per mile divided by the price of the good times 100, which is thus the percentage of the value of the good which "evaporates" due to transportation over one mile.

Table 1: Transportation Costs in Ireland, 1811

Province	No. of obs.	Cost per mile	Price of pots.	K (pots.)	K (wheat)	K (oats)
Ulster	12	.71	27.9	2.63	.36	.85
		(.024)	(1.35)	(.19)	(.015)	(.07)
Leinster	22	.75	26.4	2.79	.37	1.14
		(.095)	(2.03)	(.45)	(.047)	(.21)
Munster	11	.63	32.8	2.10	.31	.85
		(.086)	(4.40)	(.25)	(.048)	(.16)
Connaught	7	.56	30.8	2.00	.34	1.02
		(.036)	(3.06)	(.20)	(.045)	(.11)
Ireland	52	.69	29.1	2.52	.36	1.01
		(.044)	(1.31)	(.22)	(.024)	(.10)

Note: the numbers in parentheses are standard errors of the means.

Source : Wakefield, Ireland , Vol. 2, pp. 208-229.

The data indicate that potatoes cost, on average, about 2.5 percent of their value for each mile that they were transported. We can get an indication how high that is by citing a comment pertaining to modern underdeveloped economies: Clark and Haswell point out that when the cost of transport comprises three fifths

of the value, "transporting grain to market ... is economically out of the question" {22}. The Wakefield data are confirmed by data from the 1830s. The manuscript collection known as the Ordnance Survey Memoirs reports a cost of 7.2 d. per ton/mile in 1835, which amounts to .36d. per cwt./mile. {23} Since the price level in 1811 was roughly 75 percent higher than in 1835, and since some technological progress in land transport had occurred in the meanwhile, the data are consistent with those in table 1. Weld produces a set of estimates of transport costs for co. Roscommon in 1832, which average to .25d. per cwt./mile. {24} With potatoes at 1.5d. to 2d. per stone the implied value of K is between 1.5 and 2.00 for this period. Slightly higher are the figures provided by a witness from Tipperary before the Poor Law Commission, who estimated the cost of carrying potatoes over a distance of 24 miles at 1s. As the price of a cwt. of potatoes was 1s. 6d., a value of K=2.78 is implied. {25}

Furthermore, the cost of transportation is not the only cost incurred in shipping potatoes. Irregularly shaped, poorly packed, moved along bumpy roads on primitive vehicles, the the product lost much of its value in transit. A relief shipment sent by sloop from Wexford to Westport in 1835, which had been en route for only twelve days and had been shipped in a "sound and dry state," arrived in very poor condition: the potatoes had turned soft, sprouted, and fermentation had already set in. {26}

Some idea of the vulnerability of potatoes to handling and transportation can be gained from modern studies. One study examining nine 50 kg. bags of potatoes at point of wholesale

found two to have less than 5% serious damage, four to have between 9% and 14% damage, and three had over 27% damage (of which one had just over 50%). The main damage is caused by a phenomenon known as "internal bruising" or "blue spot". Even under modern transportation conditions, shipments of potatoes have been rejected because of high incidence of internal bruising after travelling 50 km. by road. {27} In prefamine Ireland, the spoilage problem was aggravated because most trade in potatoes took place in the early summer. In open carts, potatoes were exposed to higher temperatures, which led to accelerated sprouting as well to "black heart", a phenomenon of discoloration and breakdown of the inner tissue of the tuber due to asphyxiation. {28}

The same witnesses, emphasizing the lack of portability, spoke at length of the storage problems of the potato. The difficulty was that the potato could be stored cheaply in so-called clamps. Clamps are heaps of potatoes, covered with straw and turf or earth, usually set up on the side of the field. If the water table was sufficiently low, the clamp would be a pit covered with straw. {29} The efficiency and low cost of this method is demonstrated by the fact that in 1963, 48% of the potatoes stored in Great Britain were clamped. {30} While the storage costs of potatoes for a period of up to 10 months was thus very low, the cost function leaps up steeply after that and becomes essentially infinite after 12 months. Buffer stocks, consequently, were totally out of the question.

The reasons for the limited storability of potatoes

consisted of three types: disease, evaporation, and sprouting. Although all three can be controlled to some extent under modern conditions, it is clear that the Irish peasant was largely unaware of the mechanisms involved and powerless to prevent spoilage. Storage diseases were largely caused by fungi and bacteria. In particular, the disease known today as "soft rot" or "black leg", caused by bacteria, seems to have been prevalent. Bacterial multiplication is a rising function of external temperature, which explains the rotting of the potatoes by mid-summer. In clamps, things were made worse by the lack of ventilation and the consequent accumulation of metabolic heat and carbon dioxide.

The effects of these technological and physiological
ints were that every year in mid summer the Irish peasant
tarted to run out of food. In Galway and Kerry, around
rst sunday of August ("Garlick Sunday") potatoes of the
" variety were getting bad and all those who could
ed to other kinds of food. {31} A county Leitrim witness
ed his region to be fortunate because "with us, the
val between the old crop becoming unfit and the new
ing fit has never been more than a month" (PLR XXXII, p.
In Sligo, a witness said, the "lumper" and "cup" varieties
n to deteriorate as early as June. (PLR XXXII, p. 9). In
low, the months of July and August were times of great
tress and "an annual return of temporary half-famine" (PLR
II, p. 25). The "apple" variety typically kept two months
nger but was more expensive and even it did not last longer
an 12 months (PLR XXXII, p. 37). In short, there was no "means

known by which potatoes can be preserved for the next season when there is a superabundant supply" (PLR XXXII, pp. 3,19,26). The situation is neatly summarized by a witness from Kilkenny: "the supply of the principal food of the labouring classes is ... altogether dependent on the produce of one year and (from the bulkiness of the article) almost of one place ... if the crop of any year fails, distress is inevitable to the extent of the failure" (PLR XXXII, p. 13).

Potatoes were generally consumed by the people who grew them, though trade in potatoes always existed. Lord Carbery, testifying before a Parliamentary Commission in 1825 pointed out that "as long as the potatoe is the staple food, we cannot reckon much on the home market for the peasantry, for each provides for his year's subsistence ... he does not think of the market." {32} The potato led to some peculiar features in the Irish economy. One of those unique characteristics was the practice of con-acre, in which a landless laborer rented at high cost a fertilized and prepared plot of an acre or less and raised his and his family's annual food supply on it. {33} Less well-known but equally telling about the effect of the potato is the fact that many urban residents rented little plots of land just outside the town confines. On these plots they grew potatoes - presumably just for their own consumption. {34}

There is also some evidence to support the hypothesis that the reliance on potatoes worsened in the period 1815-1845 , at least as far as the mass of smallholders and landless laborers were concerned {35} . In part, the increased dependence was

caused by a growth of population. But there was another element operating here, namely, the worsening of the terms of trade of the "cash crops" bought by the smallholders and laborers in terms of those that they sold. Direct evidence on this issue is hard to come by, but there are at least two well-documented phenomena which strongly lend support to the view that "cash" was harder to produce by 1840 than by 1810. As we have demonstrated above, such a change in relative prices implies an increase in the output of the subsistence crop (potatoes) and probably led to an "encapsulation" of the potato sector in reducing what little trade there was in them.

The reduction in the cash-generating capacity of Irish peasants was caused by two main factors. The first was the decline and almost total collapse of the rural cottage industries, which had provided much of the cash income earned by Irish peasants, especially in Ulster and Connaught {36}. The demise of spinning and, a bit later, weaving, was swift, brutal, and total. Within a few years an indispensable source of "cash" had vanished. A co. Tyrone witness before the Poor Law Commissioners described the consequence as a "scramble for cash." {37} The collapse of the demand for industrial products produced by manual methods in the countryside, led to an exodus of labor back into agriculture. Much of that labor, inevitably, went into the production of potatoes. {38} Trade in agricultural goods declined. A county Down witness pointed out that he could still recall the days when spinners could get 3s. per web, and never had to sell any corn, in many cases buying their food. Now that the prices of textile products have declined to a fraction,

they are forced to depend on potatoes and sell corn to get cash. {39}

The one item in the peasant's expenditure which required cash and could not be postponed was rent. Non-payment of rent was formally a cause for eviction, an option which many Irish landlords were often all too eager to exercise. In the three decades following Waterloo, agricultural prices fell as did all prices. Most of the land in Ireland was leased at rents specified in money terms. While many landlords realized the peasants' inability to pay higher rents, many others demanded payment in full. Consequently, although the nominal value of rents declined between 1815 and 1845, real rents rose. Unlike the decline of cottage industries, the increase in real rents hit the middle sized farmers (holding between 10 and 50 acres) most severely. Many farmers, one witness explained, speculated on the high war prices and had rented land much above its value now, and "many of the landlords holding them nearly to their original engagement, have brought them to a low condition." {40} For these farmers, too, this change in prices implied a greater dependence on potatoes.

AN ECONOMETRIC APPROACH

Is it possible that the cultivation of potatoes was a factor in the impoverishment of the prefamine Irish economy? The above suggests a number of mechanisms by which the potato could

have been, in the final analysis, more of a curse than of a blessing. It is not clear, however, that potatoes actually reduced income per capita. After all, potatoes raised the productivity of labor in food production. To a large extent, the models developed above point to a reduction in security and a higher vulnerability to exogenous shocks, but not necessarily to a lower level of income per capita. Potatoes reinforced the self-sufficient subsistence sector in the Irish economy and stood in the way of its replacement by commercialized agriculture, as was occurring elsewhere in Europe. But income, by necessity, is measured in the cash sector. Is there any reason to suppose that the cultivation of potatoes had adverse effects on the commercialized sector as well?

The classical approach of nineteenth century political economy, as adopted by historians such as K.H. Connell presented a straightforward argument: potato cultivation led to increased population which, by the principle of diminishing returns, reduced income per capita. While theoretically attractive, the difficulty is that there is very little hard evidence for this hypothesis. Although it is likely that potatoes did have a positive effect on population growth, it is obvious that potatoes were not a necessary condition for population growth, since populations in Europe started to grow almost everywhere after 1750, whether potatoes were cultivated or not. More serious, however, is the objection that there is simply no support for the hypothesis that population pressure on the land was instrumental in reducing income in prefamine Ireland. [41] While the evidence is perhaps not strong enough to rule the

"classical" theory out altogether, a further search for the effects of the potato is indicated.

As noted, the chief effect of the potato was to increase the dependence of the peasant on his own harvest. At first sight, it might seem as if that dependence should show up in the variance of consumption but not in the level of income. However, if the peasant is risk averse, he would try to make an attempt to reduce his risk in other ways. Alternative forms of insurance inevitably cost something in terms of income. For instance, if the Bloch-McCloskey view of open fields is correct, peasants reduced their variance by scattering their plots. The custom of scattering known as "rundale" was still widely practiced in the poorest parts of Ireland which were most dependent on potatoes, especially in counties Donegal and Mayo. {42}

A further mechanism by which potatoes could have actually reduced income is by the absence of positive "spillover effects" of trade. Commerce had always had a larger effect on the economies engaged in them than simply providing the "gains from trade." The flow of goods was accompanied by flows of men, and with men came ideas, new technologies, and other stimuli to the production process. Learning by doing effects led to continuous improvements in transport technology, financial and commercial practices, and backward linkages to the industries catering to commerce. It would be misleading to say that Ireland with its thousands of local county fairs and advanced road system was incapable of generating these externalities. And yet, for a Western European country in the middle of the nineteenth

century, Ireland's commercialization and monetization appear stunted. Wages were often paid in provisions or conacre land. Many peasants were still largely self sufficient and although the use of money had reached everywhere, in much of the country a majority of the peasantry conducted only a small number of monetary transactions each year. Much of rural Ireland lacked retail trade networks. {43} Railroads, canals, and harbours were backward. Even the much praised Irish roads were better adapted for the carriage of tourists and commercial travellers than for heavy and bulky goods. {44} It would be foolish to blame only the potato for the underdevelopment of the commercial infrastructure of Ireland. Nonetheless, the decommercializing effects of potato cultivation cannot wholly be absolved from responsibilty for this state of affairs.

Furthermore, it could be argued that in the long run relying on potatoes as one of the mainstays of the agricultural economy constituted a "bad choice." The potato was not very conducive to rapid productivity growth. Technological progress in potato cultivation after 1800 was slow compared to other crops. In 1771 Arthur Young's calculations implied that the caloric value of an acre of potatoes was three times that of an acre of grain. Today, that gap has been entirely eliminated because the increase in grain yields has been much larger than the increase in potato yields. {45} Furthermore, savings and investment are definitely encumbered if the one of the chief sources of income consists of a crop which is <u>both</u> perishable and non-tradeable. In the extreme case, the budget constraint in the standard Fisherian two-period diagram is confined to a

single point, with no possibility of reallocation between the two periods.

These considerations suggest that the potato crop may have reduced income per capita in prefamine Ireland. To test whether that hypothesis is consistent with available data, we have to formulate a model in which income per capita is determined by the degree of dependency of the population on potatoes. Simple OLS regressions would be misleading here, since income per capita simultaneously determines the demand for potatoes through the (presumably negative) income elasticity. We use therefore a two equations simultaneous model, in which both income per capita and potatoes are endogenous.

$$(1)\quad INCOME = a_0 + a_1 POT + a_2 CAPLAB + a_3 LANDQUAL + a_4 LIT + a_5 EMPIN + a_6 PERURB$$

$$(2)\quad POT = b_0 + b_1 INCOME + b_2 CAPLAB + b_3 INFER + b_4 FMSIZE + b_5 PERURB .$$

Where:

INCOME = Income per capita around 1840.

POT = Indexes of potato acreage on the eve of the Famine.

CAPLAB = Capital-labor ratio in 1841.

LANDQUAL = Indexes of land quality.

LIT = Proportion adult population who could both read and write in 1841.

EMPIN = proportion employed population in non-agricultural occupations.

PERURB = percentage of persons living in towns over 2000, 1841.

INFER = Proportion mountain and bog land presently uncultivated which is suitable for potato cultivation.

FMSIZE = Average size of farms, Poor Law Union data, 1845.

A full description of the data and their sources cannot be attempted here. {46} The two equations were estimated using generalized two stage least squares on county data (32 observations). The results are presented in tables 2 and 3. Two columns of the same number constitute a "compatible pair" of equations in the sense that all variables are consistently defined and each equation uses the exogenous of the other as its instruments, in addition to its own.

Table 2: Regression Results of Equation 1

Dependent Variable	Income	Income	Income	Income
Constant	16.09	8.85	9.13	8.27
	(1.69)	(2.78)	(3.22)	(2.54)
Pot. acr. per cultivated area	-52.83			
	(-1.38)			
Potato acr. per capita		-14.98		-17.19
		(-1.65)		(-1.63)
Potato acr. per rural capita			-15.29	
			(-1.98)	
CAPLAB	.96	1.75	1.83	1.88
	(1.42)	(4.77)	(5.00)	(4.58)
LANDQUAL1				2.83
				(1.76)
LANDQUAL2		1.01	1.12	
		(1.88)	(2.11)	
LANDQUAL3	.0098			
	(1.18)			
LIT	-7.76	6.23	4.98	3.97
	(-.45)	(1.01)	(.82)	(.55)
EMPIN	13.29	10.29	10.11	10.54
	(2.53)	(3.17)	(3.17)	(3.11)
PERURB	12.19	6.08	10.14	6.35
	(1.91)	(2.37)	(2.98)	(2.38)

Table 2 shows that indeed potato dependency did tend to reduce income per capita, and that a is indeed negative and significant at the 10% level (one tailed test) or better. Although the results are not overwhelming, the other variables all perform quite satisfactorily. Percentage urban, non-agricultural employment, land quality, and the capital-labor ratio all have the expected positive influence on income per capita. Only literacy is disappointing. For our present purpose,

the most interesting result is the negative coefficient of the three potato dependency indices.

Table 3: Regression Results of Equation 2

Dependent Variable	Pot. Acr. per cult. acre	Pot. Acr. per capita	Pot. Acr. per rural capita	Pot. Acr. per capita
CONSTANT	.21	.34	.36	.33
	(3.11)	(4.15)	(3.73)	(3.55)
INCOME	-.0028	-.013	-.015	-.012
	(-.53)	(-2.10)	(-2.06)	(-1.67)
CAPLAB	-.031	.021	.018	.019
	(-1.64)	(.85)	(.62)	(.71)
INFER	.26	.075	.079	.085
	(2.97)	(.66)	(.59)	(.69)
FMSIZE	.0028	.0034	.0052	.0036
	(1.28)	(1.20)	(1.55)	(1.20)
PERURB	.56	.029	.027	.017
	(.56)	(1.23)	(1.89)	(.13)

NOTES TO TABLES 2 AND 3

Figures in parentheses are asymptotic t-statistics.

The land quality variables are defined as follows: LANDQUAL 1 is the proportion of all land under cultivation in 1841. LANDQUAL 2 is a nonlinear transformation of LANDQUAL 1. LANDOUAL 3 is the standard deviation of absolute elevation above sea level. For a discussion of the theory behind these proxies, cf. Mokyr, Why Ireland Starved , Ch. III, Appendix B.

Conclusions

The question posed in this paper is not new. Classical political economists wondered about the effects of potato cultivation on the people dependent on it, long before anybody

suspected that a catastrophe like the great famine was possible. Some of them, like Adam Smith, cheered the potato as a plentiful and healthy food. Malthus, on the other hand, viewed the potato with suspicion, maintaining that it led to higher birth rates, and encouraged "idleness and turbulence" {47}. From our point of view, there is perhaps more interest in the curious correspondence between David Ricardo and Maria Edgeworth, the Anglo-Irish novelist, on "the question _for_ and _against_ the potatoe which has for some hundred years past been alternately cried up as the blessing and cried down as the bane of Ireland," as Edgeworth put it {48}. Ricardo - who had been a member of an 1823 _Select Committee on the Condition of the Labouring Poor in Ireland_ - remained somewhat dubious of the beneficial effects of the potato. Only if it could be demonstrated conclusively to him that potatoes could be stored and that speculators would carry buffer stocks, Ricardo wrote, would he "fight to the death in favour of the potatoe." Edgeworth assured him that farmers in Ireland considered the potato more reliable and secure than corn, but Ricardo still had his doubts: he insisted that one had to know something about the proportional difference between an average and a deficient crop of potatoes and wheat, which determined the "comparative hazard" of the two crops {49}.

Were potatoes more risky than cereals in the sense that the crop fluctuated more violently? Although what matters ultimately is the variance of consumption and not that of production, the

latter is not without interest, since if the variance in potato production was very small, the issues of storability and tradeability become irrelevant. The answer to the question depends on time series of yields, which are not available for Ireland. Literary and circumstantial evidence suggests that in the thirty years before the great famine, partial failures of the potato harvest were becoming more commonplace, compared with the decades before. Connell speaks of a "gap in famines" between 1742 and 1815. "It is remarkable but apparently true that during eighty years of increasing dependence (i.e., 1735 - 1815), even the rumblings of disaster were seldom heard," wrote Connell, referring to the years before 1815 (50). Contemporary evidence confirms this view. In 1802 William Tighe wrote in his magisterial work on county Kilkenny that "it is a happy circumstance that the food of the majority of the inhabitants in this country consists of potatoes which are more certain in produce and less liable to injuries, and that wheat is an article of commerce rather than of food" (51). Maria Edgeworth's "clear headed farmers" told her in 1822 without hesitation that there was more chance of the wheat or oats harvest failing than that of potatoes, which he reckoned the most secure and profitable crop (52). Very similar views were expressed by witnesses before the 1825 Select Committee on the State of Ireland (53).

After 1820, however, the yield of potatoes seems to have become more variable, and complaints about bad harvests become more frequent. Combinations of frost and curl (a viral disease) seem to have been largely responsible. A list of these failures

was compiled by William Wilde and published in the 1851 Census {54}. O'Rourke, writing in the 1870s, concluded that every two or three years from 1821 to the great famine, a failure of some kind occurred in the potato crop {55}. James E. Bicheno told a Select Committee in 1830 that "potatoes are more liable to failure than hard grain" {56}. It is possible that the increased variability of the potato crop was due to the widespread adoption of the "lumper" variety, which required less fertilizer but was apparently more susceptible to failure and spoilage {57}.

It thus seems likely that in the thirty years before the great famine, the Irish were slowly becoming aware of the higher vulnerability of their "potato economy." It could be reasoned that a sufficient number of local failures coupled with a lack of cushions to absorb these shocks would have led the Irish to try to reduce their dependence on their staple diet. For the vast majority of the Irish peasants such a reversal was quite impossible, and as we have argued before, there were strong forces which led to an <u>increasing</u> dependence on the potato. The potato had become deeply entrenched in the agrarian economy as part of the crop cycle, and breaking out of that cycle required capital and expertise beyond the reach of the bulk of the peasantry. Furthermore, the potato had led to the disappearance of the "infrastructure" necessary to consume other forms of food. Millers, bakers, and even domestic utensils other than those necessary to boil potatoes were rare, especially in the South and West. In a real sense, Ireland was "locked" into a potato culture.

The net effect of the potato on the Irish economy is ambiguous and multidimensional. There can be no question that most of the positive and the negative consequences mentioned in the writings of contemporaries contained some truth. At first, the potato was undoubtedly a blessing. Yet in the final analysis the kind of economy the potato made was rigid, vulnerable, and backward. The worries of Malthus and Ricardo turned out to be more realistic than the exuberance of Arthur Young or Adam Smith. Needless to say, the potato was only one element in a complex mechanism leading Ireland to poverty and then to disaster in the nineteenth century, but it should be recognized as such.

"No ground is darker or bloodier that Europe's agrarian past," wrote William Parker in 1975 [58]. Surely, this statement holds with particular force for the hapless Irish. In the grim history of this plagued economy, the role of the potato was in small part hero, in large part villain. The counterfactual question seems unavoidable: what would Ireland's history have been like without the potato? It seems hard to imagine that without the potato Irish history could have been more tragic.

FOOTNOTES

{1} William N. Parker, "Productivity Growth in American Grain Farming: An Analysis of its 19th Century Sources," in R.W. Fogel and S.L. Engerman, eds., The Reinterpretation of American Economic History ,N.Y., Harper _ Row, 1971, p. 176.

{2} Often, such examples stem from productivity changes which lead to intensified exploitation of a resource which, due to some market failure, is in danger of being overexploited. A striking example is the California sardines industry which was all but annihilated by the introduction of diesel engines in fishing vessels. See Arthur McEvoy, "Economy, Law, and Ecology in the California Fisheries to 1925," Unpublished Ph.D. dissertation, Univ. of California San Diego, 1979.

{3} Robert A. Dickler, "Organization and Change in Productivity in Eastern Prussia," in William N. Parker and Eric L. Jones, eds., European Peasants and their Markets , Princeton: Princeton University Press, 1975, p. 288.

{4} Potatoes are a labor- and fertilizer intensive crop, so that it is reasonable to think that potato cultivation only became profitable in low wage societies. This argument has been made by L.M. Cullen, "Irish History Without the Potato," Past and Present Vol 40 (July 1968), pp. 72-83. For a further elaboration and an attempted test of the Cullen hypothesis, see Joel Mokyr, "Irish History With the Potato," Irish Economic and

Social History Vol. VIII, (1981), forthcoming.

{5} At five tons per statute acre, total output of a one and a half acre potato garden would be on the order of 16,600 lbs. per annum. If we assume that half that amount was consumed by humans, potatoes alone provided more than 8,600 calories per day. For more details, cf. P.M. Austin Bourke, "The Use of the Potato Crop in Pre-famine Ireland," Journal of the Statistical and Social Inquiry Society of Ireland , Vol. XII (1968), pt. VI, pp. 72-96.

{6} The view that population growth, caused by the adoption of the potato, eliminated the gains in living standards which a more efficient source of food supply made possible constitutes the core of the classic interpretations of K.H. Connell and N.R. Salaman. Cf. K.H. Connell, The Population of Ireland, 1750-1845 , Oxford: at the Clarendon Press, 1950 and N. Redcliffe Salaman, The History and Social Influence of the Potato , Cambridge: Cambridge University Press, 1949. For a critique of Malthusian theories of this type, see Joel Mokyr, Why Ireland Starved: A Quantitative and Analytical History of the Irish Economy 1800-1850 , London: Allan and Unwin, forthcoming.

{7} The correlation between potato consumption and poverty has been widely noted. See for instance Michel Morineau, "The Potato in the Eighteenth Century," in Robert Forster and

Orest Ranum, eds., Food and Drink in History , Baltimore: the Johns Hopkins University Press, 1979, pp.24-25. Stanley Davidson and R. Passmore, Human Nutrition and Dietetics , Baltimore: The Williams and Wilkins Co., 1965, p. 285. D. Warriner has called potatoes "poor man's crops and poor man's foods" ,cited by Jerome Blum, The End of the Old Order in Rural Europe ,Princeton: Princeton University Press, 1978, p. 271. Among contemporary writers, none was so explicit in his denunciation of the potato as William Cobbett, who termed the potato "that root of wretchedness," and emphasized the dangers inherent in the dependence on a subsistence agriculture based on potatoes.

{8} The local and limited nature of the trade in potatoes was also widely observed in Eastern Europe. Cf. Dickler, "Organization and Change," p. 289.

{9} Cf. J.S. Donnelly, The Land and People of Nineteenth Century Cork , London: Routledge and Kegan Paul, 1975, p. 29. See also, Mokyr, "Irish History," n. 12. The potato is superior to the turnip in that its crop is edible to human beings, but turnip crops were much larger and to the extent that both crops were used as animal fodder, the turnip was preferable. As a crop rotating with cereals, the two seem to have been about equally effective.

{10} The potato economy in Ireland implied small farms as there were no significant technical economies of scale in

potato production. Scale-augmenting technological change in grain crops or animal husbandry implied a desire by landlords to consolidate the farms into larger units, but resistance of the smallholders prevented such attempts in many cases.

{11} For a detailed discussion, see Mokyr, Why Ireland Starved , Ch. V.

{12} The alternative to looking at the variance of the logarithms is to specify (3) as a linear (non-constant elasticity) demand function which is comparatively awkward.

{13} Howard Kunreuther and Gavin Wright, "Safety-first, Gambling, and the Subsistence Farmer," in James A. Roumasset et. al., eds., Risk, Uncertainty, and Agricultural Development , College Laguna, Philippines: Southeast Asian Regional Center for Graduate Study and Research in Agriculture, 1979, p. 217.

{14} In some ways, peat resembled the potato in the type of constraint it imposed on the economy. Like potatoes, it was a cheap and ubiquitous source of energy. Peat too, was largely used in the area where it was cut, and most of it was extracted by the user himself.

{15} In practice, the "marketing cost" will be shared by the seller and the buyer, but in order to keep the analysis

simple, we shall abstract from its distribution.

{16} The following draws heavily on Mokyr, Why Ireland Starved , chapter V.

{17} Joseph Lee, "The Ribbonmen," in T.D. Williams, ed., Secret Societies in Ireland Dublin: Gill and Macmillan, 1973, pp. 26-35.

{18} Great Britain, H.C., Parliamentary Papers , 1836, Vols. XXXI - XXXIV, "Reports of the Commissioners for Inquiry into the Conditions of the Poorer Classes in Ireland." Henceforth referred to as PLR (Poor Law Report).

{19} Great Britain, H.C., Parliamentary Papers , 1825, Vol. VIII, "Reports from the Select Committee on the State of Ireland," p. 317.

{20} Edward Wakefield, An Account of Ireland, Statistical and Political , London: Longmans, 1812, Vol II, p. 199.

{21} ibid., , pp. 197-202.

{22} Colin Clark and Margaret Haswell, The Economics of

Subsistence Agriculture , London: Macmillan, 4th edition, 1970, p. 191.

{23} Royal Irish Academy, Dublin, Ordnance Survey Memoirs, Box 31 File I, pertaining to the parish of Ballywillen, co. Londonderry.

{24} Isaac Weld, Statistical Survey of the County of Roscommon , Dublin: R. Graisberry, 1832, p. 175.

{25} PLR, XXXII, p. 8.

{26} ibid., p. 30.

{27} W.G. Burton, The Potato: A Survey of Its History and of Factors Influencing its Yield, Nutritive Value, Quality and Storage , Wageningen: H. Veenman and Zonen, 2nd edition, 1968, pp. 197, 209.

{28} ibid., pp. 230-231.

{29} Salaman, The History , pp. 235-236.

{30} Burton, The Potato , p. 266.

{31} PLR, XXXII, pp. 4,27.

{32} Parliamentary Papers , 1825, Vol. VIII, p. 615.

{33} For more details on con-acre, see for instance M.R. Beames, "Cottiers and Conacre in Pre-famine Ireland," Journal of Peasant Studies , Vol. 2, no. 3 (April 1975), pp. 352-55. Donnelly, The Land and People , pp. 19-21.

{34} PLR, XXXIII, p. 240 (pertaining to the town of Kilkenny). Ordnance Survey Memoirs, Box 27, File I (pertaining to Enniskillen), Box 39, File II (pertaining to Dungiven, co. Londonderry).

{35} The 1841 Census of Ireland reported that 67.9% of the rural population of Ireland were laborers, smallholders, and other persons "without capital,in either money, land, or acquired knowledge." The Poor Law Unions data on farm size show that 75.2% of all farms were under 20 acres, of which 55.0 were under 10 acres.

{36} See for instance Conrad Gill, The Rise of the Irish Linen Industry , Oxford: at the Clarendon Press, 1925, pp. 322-329. Eric L. Almquist, "Mayo and Beyond: Land, Domestic Industry, and Rural Transformation in the Irish West," unpublished Ph.D. dissertation, Boston University, 1977.

{37} PLR, XXXI, p. 391.

{38} Ordnance Survey Memoirs, Box 3, file V; Box 9 file VI; Box 13, file I; Box 36, file VI.

{39} PLR, XXXII, p. 312.

{40} PLR, XXXI, p. 329.

{41} See Mokyr, Why Ireland Starved , Ch. III.

{42} For an application of the Bloch-McCloskey framework to the West of Ireland, see Almquist, "Mayo and [illegible]," pp.118-22

The province of Connaught, for instance, with a [illegible]l occupied adult population of 560,000 in 1841, had less [illegible]n one half of a percentage of them in occupation which fall [illegible]der the heading of "commerce and finance." Many of these were [illegible]olesale traders of cattle produced by the large grazier farms [illegible]n the West. By comparison, in 1846 5.2% of the French occupied [illegible]opulation were classified in commerce and finance, 3.5% of the Belgian workers, and 1.8% of the British. Although inconsistencies in definitions present many pitfalls in the comparison of different countries, the gap between the Irish

West and the other countries is striking.

{44} Gearoid O Tuathaigh, Ireland Before the Famine, Dublin: Gill and Macmillan, 1972, p. 121.

{45} Davidson and Passmore, Human Nutrition , p. 285 Burton, The Potato , p. 181.

{46} Details on the data can be found in Mokyr, Why Ireland Starved , and Mokyr, "Irish History."

{47} Adam Smith, The Wealth of Nations ,ed. Edwin Cannan, Chicago: The University of Chicago Press, 1976, p. 179. Thomas R. Malthus, An Essay on the Principle of Population , London: John Murray, 6th ed., 1826, Vol. II, p. 393.

{48} David Ricardo, The Work and Correspondence of David Ricardo , ed. Piero Sraffa, Cambridge: At the University Press, 1952, Vol IX, pp. 230-231, emphasis in original.

{49} ibid., , p. 259.

{50} Connell, Population of Ireland, p. 146.

{51} William Tighe, Statistical Observations Relative to the County of Kilkenny . Dublin: Graisberry and Campbell,

1802, p. 191.

{52} Ricardo, Works and Correspondence , p. 253.

{53} Parliamentary Papers , 1825, Vol. VIII, pp. 312, 416, 615.

{54} Great Britain, H.C., Parliamentary Papers , 1856, Vol. XXIX, "The Census of Ireland for the year 1851, part V, Tables of Death, Vol.I," pp. 502-06. Wilde pointed to 1813-14 as the season which was the "forerunner of other calamities ... a new pestilential constitution now commenced."

{55} J.O'Rourke, The History of the Great Irish Famine of 1847 With Notices of Earlier Irish Famines , Dublin: James Duffy and Co., 3rd., 1902, p. 34.

{56} Great Britain, H.C., Parliamentary Papers , 1830, Vol VII "Second Report of Evidence from the Select Committee on the State of the Poor in Ireland," p. 378. Bicheno was more cautious in his book which appeared that year, cf. id., Ireland and its Economy , London: John Murray, 1830, pp. 20-21.

{57} The "lumper" variety was definitely more susceptible to the 1845-46 blight which was caused by a fungus.

See W.D. Davidson, "History of Potato Varieties," Journal of the Department of Agriculture (Dublin), Vol. XXXIV, No. 2 (1937), p. 64.

{58} Parker and Jones, European Peasants and Their Markets.