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ABSTRACT

Giffen's Good: A case of mistaken identification*

Giffen reported that, in the late nineteenth century, English wheat consumption rose when its price increased – the first recorded "Giffen good". Using Giffen's data, I explain how he reached his conclusion. I then show that his analysis was faulty: price elasticity of demand appears positive when the demand curve is incorrectly identified, but is significantly negative – like any normal good – when it is correctly identified. Since the pathological Giffen good case was actually just mistaken identification, it is no surprise that Giffen goods are impossible to find elsewhere. Popularization of the Giffen good stemmed from Marshall's and Samuelson's influential textbooks.

JEL Classification: B13, B16 and D12
Keywords: endogeneity, Giffen good, identification and stationarity

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0. Introduction. The "Giffen good" (or "Giffen Paradox") has fascinated economists – both theoretical and applied – for almost 120 years. Theorists have carefully defined it; applied economists have carefully searched for it; and yet – remarkably – no one has managed to find it. Except, it seems, Sir Robert Giffen. I propose a simple explanation that may reconcile these facts. The Giffen good has never existed, and Sir Robert never observed it. He was mistaken.

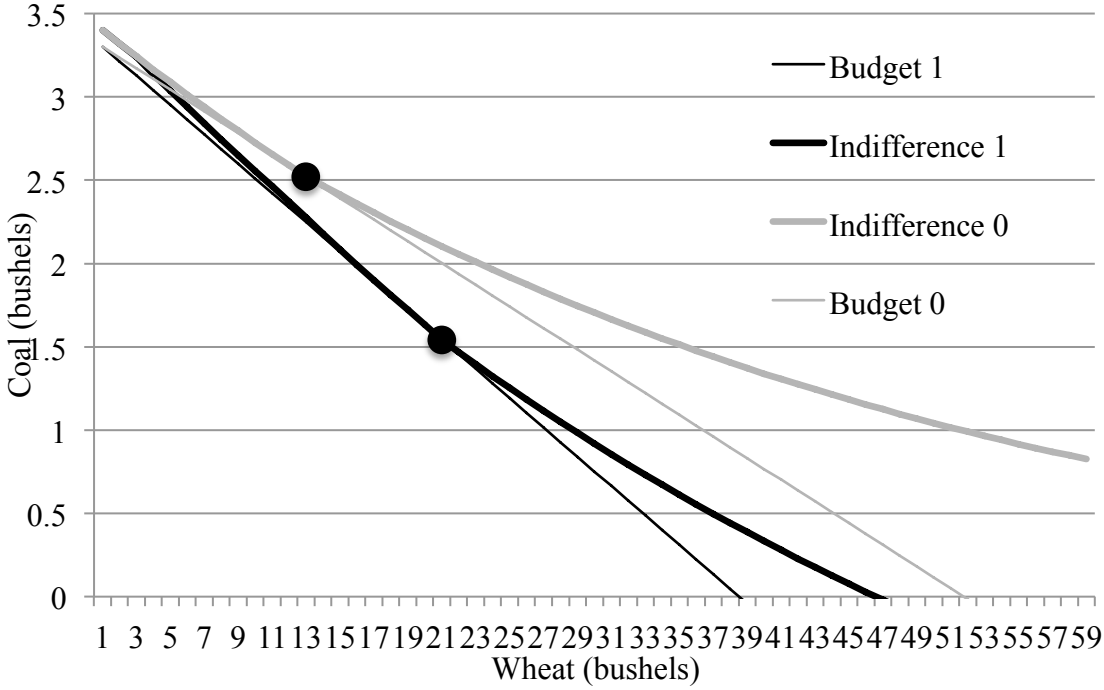
To understand how this error was made, I go back to Giffen's original example, the demand for wheat in England in the late nineteenth century. A simple analysis of Giffen's data appears to reveal the existence of a Giffen good, just as he described. But this appearance stems from an incomplete analysis of the data – something that he himself could have seen if he had plotted the data differently. A rigorous, modern reanalysis of the data reveals that wheat was a perfectly normal good in late nineteenth century England. Strangely, no one seems to have taken a second look at Giffen's data, even though they are readily available.

I begin in section 1 by defining and illustrating the Giffen good. In section 2, I consider the attempts of other economists to find one. In section 3, I present Giffen's data and show how he reached his conclusion. In section 4, I show why Giffen's inference was false. I then reanalyze the data in order to draw a valid inference about the price elasticity of demand, showing that it was perfectly normal. In section 5, I discuss why the Giffen good concept became so popular, despite its apparent absence from the real world. Section 6 concludes.

1. What is a Giffen good? For simplicity, suppose that the consumer purchases two goods – coal and wheat. Suppose that the consumer also has diminishing marginal utility (i.e. he gets less utility from each extra unit of any good that he consumes). The consumer sets the marginal utility that he derives from each good equal to the marginal cost (price) of it. He does this by purchasing more and more units of each good until – at the margin – the utility he gets from the extra unit equals the cost (price). A rational consumer would never pay more for a unit of a good than the utility that he derived from it; and he would also want to buy extra units whenever the utility derived from the good was greater than the price. This is what drives the consumer to his optimal consumption pattern of the two goods, given the prices that he faces and his preferences.

How can we summarize this situation? We can graph the consumer's *indifference curve* and his *budget constraint*. The indifference curve describes the loci of points at which the consumer is indifferent between alternative bundles of coal and wheat. Take indifference curve *Indifference 0* in figure 1 below. The consumer is indifferent between a bundle containing 3.4 bushels of coal and 1 bushel of wheat; and a bundle containing 0.9 bushels of coal and 59 bushels of wheat; and any of the other bundles on the curved line in between. The line is curved because the consumer has diminishing marginal utility of both coal and wheat. The budget constraint describes the set of feasible combinations of coal and wheat, given the consumer's income and the prices of coal and wheat. So, in figure 1 below, take the budget constraint *Budget 0*. The consumer could buy 3.4 bushels of coal and 0 bushels of wheat; or 0 bushels of coal and 51 bushels of wheat (or any combination on the straight line in between).

Figure 1. Indifference curves displaying Giffen behavior.



Suppose that the price of wheat rises and the price of coal remains unchanged; then the budget line pivots downwards to *Budget 1*. The consumers can still purchase 3.4 bushels of coal and 0 bushels of wheat because the price of coal has not changed. But the consumer can now purchase a maximum of 38 bushels of wheat and 0 bushels of coal. The consumer wants to maximize his utility by reaching the highest possible indifference curve (so *Indifference 0* is preferred to *Indifference 1*). This occurs where the budget constraint is tangential to an indifference curve (the black dots in figure 1).

When the price of any good changes, there are two effects on the consumer's optimization decision – the substitution effect and the income effect. First, consumers will substitute away from wheat and towards coal, in our example. This follows from the fact that the marginal cost of wheat has risen; in order to set it once again equal to the marginal utility of wheat, fewer units of wheat must be consumed (in order for the consumer to work his way up the marginal utility curve). Second, the consumer's real income falls when the price of something in his consumption bundle rises. When the consumer's real income changes then his consumption choice may change. He may choose to consume the same, more or less of any particular product. If the consumption of a good rises when income falls then it is called an inferior good. We would typically think of wheat as being in this category.

The special feature of a Giffen good is that it demonstrates a positive income effect that is *larger* than the negative substitution effect. So consumers substitute away from wheat when the wheat price rises. But their real income falls to such an extent that they can no longer afford to consumer other forms of calories (such as meat). Therefore, there is a positive income effect on wheat consumption arising from the wheat price increase. This effect is so strong that total consumption of wheat rises when the wheat

price rises. This is illustrated in figure 1 above, where the rise in the wheat price raises the optimal consumption of wheat from 12 bushels to 20 bushels. This violates the standard "law of demand", which states that the quantity demanded of a good falls when the price rises.

2. Who ate all the Giffen goods? Numerous economists have searched for Giffen goods. They have looked in a variety of times and places, and examined a variety of food products. This paper is not even the first to analyze wheat consumption in the UK in the nineteenth century, in order to judge whether wheat was indeed a Giffen good.

Stigler offered the first modern analysis of UK wheat demand around 1900, specifically searching for evidence that wheat was a Giffen good.[2] Stigler offers two types of data to support his analysis.

First, Stigler presents data on per capita wheat consumption and price for the period 1890-1904 (table 1, p. 155). He remarks – correctly – that the two series are negatively correlated. There are several problems with these data. First, they do not pertain to England: they pertain to the United Kingdom (i.e. they include Scotland and Ireland). This is rather important because Scottish and Irish consumption patterns were very different to English patterns, relying much more on oats. The consumption patterns of the Irish, in particular, were also changing fast in this period, owing to an economic rebalancing after the Famine; so the Irish data are likely to have all kinds of divergent trends.[3] The disadvantage of aggregating sub-populations will become very apparent when we consider the Jensen and Nolan evidence in a moment. Second, the Comptroller of Corn Returns did not deal with Scottish and Irish data, only English – so Giffen was almost certainly not referring to these data when he remarked upon his Paradox. Third, if we undertake the same exercise with English data then we find a *positive* correlation between price and per capita consumption over the period 1890-1904. Fourth, Stigler's data pertain to a period largely subsequent to Giffen's period of observation, since the Paradox had already appeared in print in 1895.

Stigler's second piece of evidence (table 2, p. 155) is a cross section of United Kingdom household budgets for 1904, as reported by the Board of Trade. Several of the previous criticisms carry over also to these data: they pertain to the United Kingdom, they occur after Giffen observed the Paradox. Stigler uses the budget data to try to infer the income elasticity of bread. Leaving aside the rather primitive nature of the analysis, it is not clear that this is anyway a relevant exercise. Bread may have a negative income elasticity (i.e. be an inferior good); but this alone cannot tell us whether it is a Giffen good because this depends also upon the relative magnitude of the price elasticity. So the validity of Stigler's inference hinges entirely on the first set of data that he presents.

Overall, the fact that Stigler finds no evidence that wheat was a Giffen good in the United Kingdom around 1900 is not really relevant to the case at hand. This is the wrong place to look. Giffen was referring to England between 1860 and 1900, and it makes sense to look there if we want to verify his results and understand why he reached the conclusion that he did.

[2] Stigler, "Notes".
[3] Brunt and Cannon, "Irish grain trade".

A similar situation arises with the analysis of Koenker.[4] He considers the demand for bread in England around 1790, using the household budgets famously collected by Davies and Eden. He finds that the price elasticity of demand is negative – like any normal good – and that therefore bread cannot be a Giffen good. Obviously, this is open to the previous criticism that Giffen was referring to 1890, rather than 1790, and demand patterns may have changed over a century. It would be no surprise if bread were a Giffen good in 1890 but not in 1990. More fundamentally, it is not clear that it is valid to draw inferences about time series behavior from cross sectional evidence (a critique that applies also to Stigler's budget analysis). The reasoning runs as follows. It may be the case that people habitually consume less wheaten bread in places where it is expensive; instead they may habitually consume something different – such as pea bread, rather than wheaten bread, as was common in the north of England around 1770.[5] But this does not tell us much about the reaction of habitual consumers of wheaten bread to a shock to the prices that they face. In fact, it is unlikely that those consumers switch to pea bread. They are likely to have such a strong taste for wheaten bread that they refuse to give it up – even when prices are high – and prefer to suffer a more serious adverse income shock. This may prompt them to cut back on other goods, such as meat, in order to buy even more wheaten bread. This type of inflexible behavior (a strong reluctance to substitute over time) is well documented for various places and periods.[6]

The most popular area in which to search for Giffen goods has, in fact, been Ireland during the Famine. Samuelson popularized the idea that Giffen had proposed potatoes in Ireland as an example of a Giffen good.[7] We discuss Samuelson's contribution in more detail later, but here we consider whether potatoes were indeed a Giffen good in Ireland. There have been several research papers on this topic.

In a most damning critique, Dwyer and Lindsay pointed out that potatoes could not possibly have been a Giffen good in Ireland around the time of the Famine.[8] First, the Giffen Paradox requires that consumption of the inferior good rises as the price rises. But the Irish Famine was caused by the potato blight, a disease that decimated the potato harvest. Potato supply (and therefore consumption) *must* have fallen during the Famine. *Ergo*, potatoes were not a Giffen good. Second, suppose that potatoes were a Giffen good and that the demand curve was therefore upward sloping (higher prices are correlated with larger quantities). Then the reduction in the supply of potatoes would have *reduced* the price of potatoes – the exact opposite of what happened.[9]

One of the issues raised by Dwyer and Lindsay is whether the potato was anyway an inferior good in Ireland. It may have been so elsewhere, but the level of poverty in Ireland at that time may have meant that potatoes were actually a superior good. Read considers this issue in more detail by examining whether *any* foodstuffs in Ireland around

[4] Koenker, "Was bread Giffen?"
[5] Young, *Northern tour*.
[6] For example, Logan and Rhode, "Movable feasts".
[7] Samuelson, *Economics*.
[8] Dwyer and Lindsay, "Robert Giffen".
[9] Kohli, "Robert Giffen", points out that the story may be more complicated in a general equilibrium setting. However, he does not dispute their basic conclusion that potatoes could not have been a Giffen good.

the time of the Famine were Giffen goods.[10] He concludes that potatoes, wheat, barley and oats were all normal goods.

To the best of our knowledge, the only paper that has found any evidence for the existence of a Giffen good – albeit not statistically significant evidence – is that of Jensen and Miller.[11] They carefully construct a field experiment focused on the urban poor in China. By giving subsidy vouchers for rice or wheat, Jensen and Miller were able to artificially lower the price of the local staple food (rice in the southern province of Hunan, wheat in the northern province of Gansu). The result of this exercise is that the reduction in the price induced some people to reduce their consumption of rice in Hunan. These people were not the poorest of the poor – the poorest of the poor obtain more than 80 per cent of their calories from rice, and are so poor that they cannot afford to consume almost any other foodstuff; so price reductions for those people result in higher rice consumption (i.e. rice is a normal good for them). The subset of people who exhibited Giffen behavior were very poor but had enough calories to want to consume something else, in addition to rice (thus they were in an economic position permitting them to substitute away from rice when the price went down). Whilst Jensen and Miller demonstrate admirable persistence and excellent experimental technique, the overall impression is that Giffen goods are very hard to find. Moreover, looking at more aggregated data would seem to be doomed to failure – such a small minority of people (even poor people) are in a position to exhibit Giffen behavior that their actions must generally be outweighed by the majority of consumers. So a good will appear to be normal overall, even if it is Giffen for a subset of consumers. This raises an obvious question: where did Giffen manage to find evidence of his Paradox?

3. How did Giffen "find" a Giffen good? From 1876 onwards, Giffen was the Chief of the Statistical Department and the Comptroller of Corn Returns.[12] This is important because it gave Giffen exceptional access to large amounts of data on English grain prices and quantities traded. Hence we begin with a consideration Giffen's role as Comptroller of Corn Returns and the data that were available to him.

Comptroller of Corn Returns was an important position in nineteenth century England. Since 1770, Parliament had placed a legal obligation on local Justices of the Peace to provide weekly returns of all grain traded in a set of market towns in each county, listing the quantities traded at each price. These returns were forwarded to the Comptroller of Corn Returns in London and he calculated town, county, regional and national average prices of wheat, barley, oats, peas and beans (the "corn averages"). In the eighteenth and early nineteenth centuries, these corn averages were used to determine whether grain could be imported into England and, if so, at what tariff.[13] After the repeal of the Corn Laws, the corn averages took on a different role. From 1836 onwards, the tithe in England was commuted into a fixed payment. The advantage of commutation was that it reduced the disincentive of farmers to increase output (since it no longer taxed marginal increases in gross output at ten percent). The problem was that commutation

[10] Read, "Giffen behaviour".
[11] Jensen and Miller, "Giffen behavior".
[12] Mason, *Robert Giffen*, 16.
[13] Brunt and Cannon, "Truth".

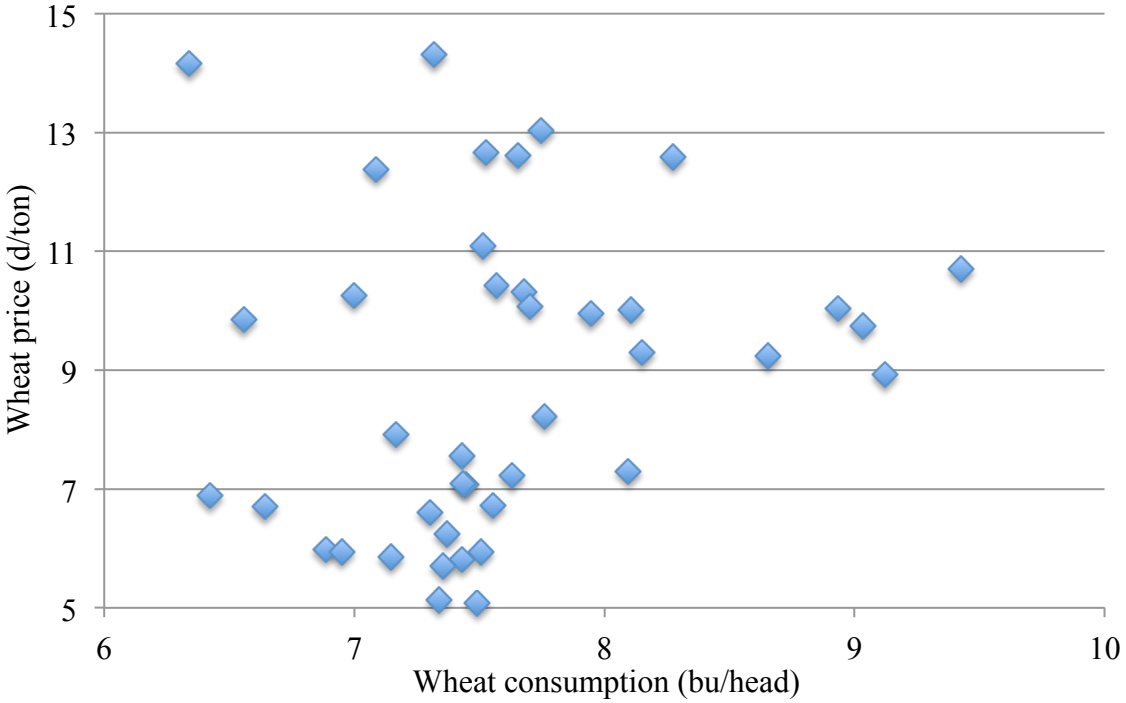
was potentially unfair to the tithe-holder because, if grain prices rose, then the real value of a fixed money payment would fall. This problem was solved by allocating the tithe-holder a fixed quantity of grain, but valuing it at current market prices. The official market price was determined by the corn averages. In the late nineteenth century, there was considerable friction between farmers and tithe-holders about how the corn averages were calculated and whether they were either inaccurate or biased. In his official position as Comptroller of Corn Returns, Giffen wrote a number of influential papers that examined, in microscopic detail, these data on prices and quantities traded.[14] Thus Giffen was, without doubt, the pre-eminent expert on English grain prices and the internal grain trade.

There were other important sources of data readily available to Giffen. First, there were annual English output data. From 1884, annual estimates of English grain output were available from the official agricultural returns (published annually in the British Parliamentary Papers). Between 1867 and 1884, acreage data were available but not yield data; before 1867 there were no official data available. However, this gap was filled by Lawes and Gilbert.[15] They ran the Rothamsted experimental farm – the world's first experimental farm, which made important scientific advances in both agronomy and statistics.[16] Lawes and Gilbert collected vast amounts of data and used some of it to estimate English wheat output back to 1853 in quite a sophisticated way.[17] Second, there were data on grain imports and exports. These were published annually in the trade accounts reported in the British Parliamentary Papers.[18] This is key because English *consumption* actually depends upon domestic output plus net imports – which were very large and growing strongly throughout this period. Third, population data were available from the decadal census, again published in full in the British Parliamentary Papers.

From these data, Giffen was able to calculate English wheat consumption per head, and plot it against the English wheat price. The time period that Giffen examined is not known with certainty. The Lawes and Gilbert output data go back only to 1853, so it is highly unlikely that Giffen looked at data prior to that date. We know that he must have based his initial conclusions on data prior to 1895, since that is when the Giffen Paradox is first mentioned by Marshall. And Marshall stated in 1903 that Giffen formulated the Paradox on the basis of data "for the last forty or so years".[19] In fact, it makes very little difference exactly which start and end dates we choose, as we consider in more detail later. So here we plot the data for 1863-1903, as reported in figure 2 below.

[14] Giffen, "*Gazette*"; British Government, "Corn averages"; British Government, "Corn (measures and weights)".
[15] Lawes and Gilbert, "Report"; "Continuous growth".
[16] Hall, *Book*.
[17] A good indicator of their rigorous approach to statistics is the fact that they hired Fisher. Whilst he was based there, 1919-33, he invented the F-statistic, regression analysis, ANOVA and maximum likelihood in order to analyze the data generated by the Rothamsted agronomists; see Spencer, "Fisher".
[18] For convenience, we take the data from Mitchell, *Abstract*, where they are republished.
[19] Marshall, "Memorandum", 9 (para. 25). Mason, *Robert Giffen*, 61-6, suggests that the Paradox may have been noted around 1880.

Figure 2. English wheat price and per capita consumption, 1863-1903.



Sources: see text.

These data do indeed reveal a positive relationship between per capita wheat consumption and the English wheat price. The correlation coefficient for the period 1863-1903 is 0.18 (p=0.25). Depending on the exact time period chosen between 1853 and 1913, the correlation is around 0.2-0.25 and is generally significant at the 5-10 per cent level.

The original formulation of the Giffen Paradox is actually slightly ambiguous – in particular, as to whether it pertains to the demand for bread or the demand for wheat. Giffen himself never published a word on the matter. Marshall stated on multiple occasions that Giffen had pointed out the Paradox to him, but he uses the cases of bread and wheat interchangeably. He first noted the Paradox in the third edition of his textbook, *Principles of economics*, which appeared in 1895:

"Mr. Giffen has pointed out, a rise in the price of bread makes so large a drain on the resources of the poor laboring families and raises so much the marginal utility of money to them, that they are forced to curtail their consumption of meat and the more expensive farinaceous foods: and, bread being still the cheapest food which they can get and will take, they consume more, and not less of it." (Marshall, *Principles*, p. 208).

He later noted in his evidence to the House of Commons:

"Sir R. Giffen seems to have been the first to observe, a rise in the price of wheat still leaves bread the cheapest food, which they will consent to eat in any quantity; so that,

having to curtail their purchases of more expensive foods, they buy, not less bread than they would have done, but more." (Marshall, "Memorandum", p. 9, para. 25.)

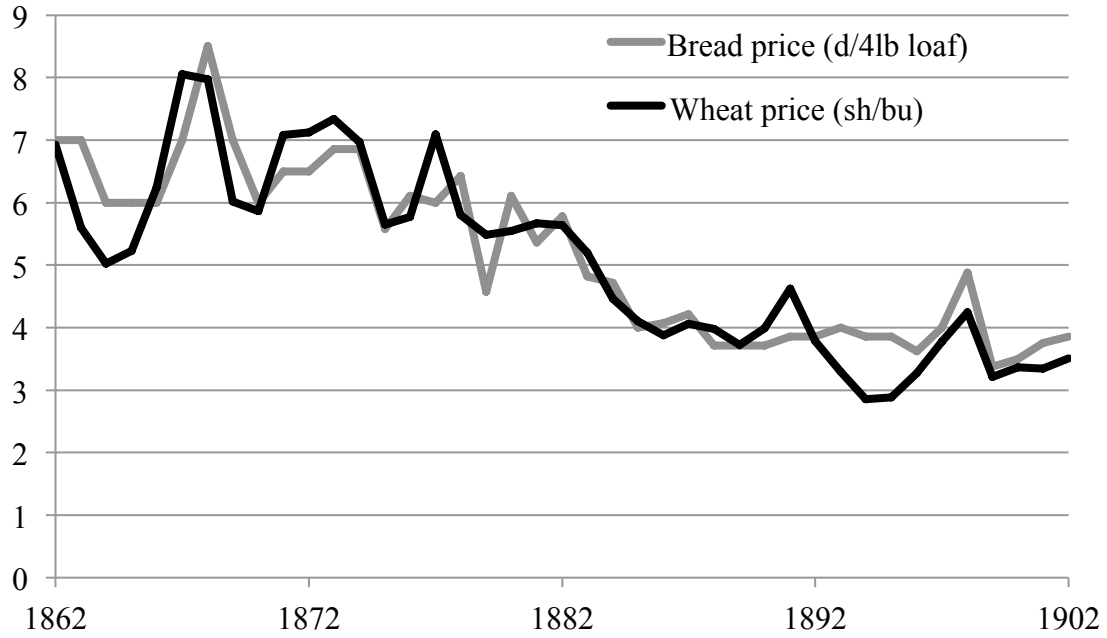
The economist Rea had written a book on free trade in 1908 in which he stated – as if it were an established fact by that stage – that: "a rise in the price of wheat would increase rather than decrease the consumption in this country".[20] Edgeworth was rather scathing about this suggestion, noting that: "Even the milder statement that the elasticity of demand for wheat *may* be positive, although I know it is countenanced by high authority, appears to me so contrary to *a priori* probability as to require very strong evidence."[21] Interestingly, Marshall defended Giffen's view in response to criticism by Edgeworth, writing to him that:

"I have just noticed your review of Rae [*sic*] in the Ec. J [XIX (1909), 102]. I don't want to argue. But the hint that a rather rash and random guess has been made by those who suggest that a (moderate) rise in the price of wheat might increase its consumption in England (not generally) provokes me to say that the matter has not been taken quite at random." (Marshall, *Memorials*, p. 438.)

In fact, the price of bread was tied very closely to the price of wheat because the cost of baking, and the mark-up charged by bakers, changed very little over time. We can see this by plotting the two data series in figure 3 below. Our further discussion will focus on wheat, for two reasons. First, it was a more homogeneous good – so we can be sure that variations in price reflect the cost of a standard product, not variations in quality. Second, bread consumption was not observed directly – only inferred from the consumption of wheat – and we prefer to keep our analysis as direct as possible.

[20] Rea, *Free trade*, 126.
[21] Edgeworth, "Free trade", 104-5.

Figure 3. The prices of bread and wheat in England, 1862-1902.



Sources: bread price from Board of Trade, "Report"; wheat prices as in figure 1.

The data appear to show that Giffen was correct – rises in the wheat price were associated with a rise in consumption, rather than a fall. This seems to have been accepted by the great economists of the age, except Edgeworth. So, surely, the case is closed? Unfortunately, the analysis offered above is very incomplete – even by the standards of its era, let alone by the standards of today. A more rigorous analysis reveals that Giffen and Marshall were quite wrong: wheat was not a Giffen good in late nineteenth century England.

4. What was Giffen's mistake? Suppose that we interpret the positive correlation between wheat prices and per capita consumption as a positive price elasticity of demand (i.e. the existence of a Giffen good). There are (at least) three major pitfalls in drawing such an inference.

The first pitfall is that there are likely to be additional important elements in the demand function for wheat – typically income, the price level and the prices of substitute goods. If we omit these elements from our analysis then we may erroneously ascribe their impact to the price of wheat (what an econometrician would call "omitted variable bias"). Since Marshall was the first person to write down demand and supply functions – in his book, *Principles of Economics* – the existence of these other elements in a properly specified demand function were known at the time Giffen proposed his Paradox. A reasonable demand function could be written:

$$Q^{demanded} = \alpha + \beta_1 P^{wheat} + \beta_2 Y + \beta_3 P^{substitutes} + \beta_4 CPI + \varepsilon \qquad (1)$$

where $Q^{demanded}$ is the quantity demanded, α is a constant, P^{wheat} is the price of wheat, Y is income, $P^{substitutes}$ is the price of substitute goods, CPI is the price level, ε is an error term and β_1 to β_4 are the parameters (elasticities) of the model. No one could estimate the parameters of a multivariate model like this in the late nineteenth century. Instead, at the time of the debate between Marshall and Edgeworth, economists were limited to estimating a bivariate model, such as:

$$Q^{demanded} = \alpha + \beta_1 P^{wheat} + \varepsilon \qquad (2)$$

Here the estimation problem collapses to a simple expression involving the standard deviations of two variables (i.e. price and quantity, in this case) and their correlation. Lehfeldt used this approach in 1914 to estimate the elasticity of demand for wheat.[22] In fact, we will see below that omitted variable bias is *not* the source of error in Giffen's analysis – including income and the price level leaves the estimated price elasticity of demand completely unchanged.

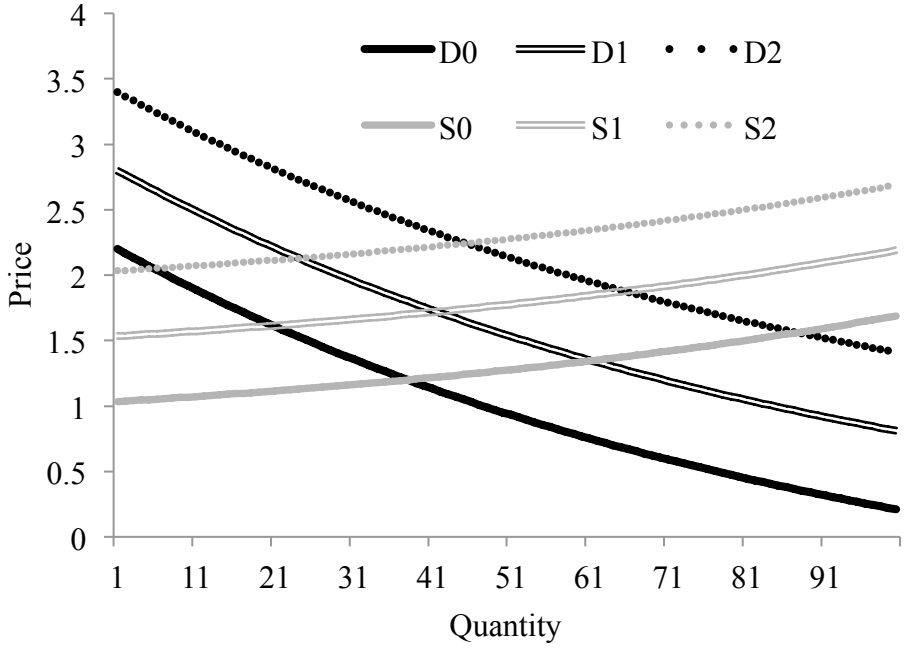
Now consider the second pitfall. Figure 2 above simply reports a set of price-quantity pairs (i.e. the quantities and prices at which the market cleared each year). But why would we move from one price-quantity pair to another? Either the demand curve or the supply curve, or perhaps both, must have moved. If the supply curve moves – but the demand curve stays fixed – then the loci of points that we observe describe a static demand curve. This is ideal for Giffen because he can then correctly interpret the slope as the elasticity of demand. This situation is sketched in figure 4 below, where S_0, S_1 and S_2 are annual supply curves that trace out the static demand curve, D_0. But suppose, instead, that the supply curve S_0 stays fixed and the demand curve moves from D_0 to D_1 and D_2; then the annual demand curves have traced out the supply curve and the slope that we calculate is actually the elasticity of supply. This would be a severe problem for Giffen – he would have observed the supply curve, instead of the demand curve, and we would actually be quantifying the elasticity of supply. A simple way of seeing this is to write down a simple supply equation:

$$Q^{supplied} = \gamma + \delta_1 P^{wheat} + \tau \qquad (3)$$

where $Q^{supplied}$ is the quantity supplied, γ is a constant, P^{wheat} is the price of wheat, τ is an error term and δ_1 is the supply parameter (elasticity). Equation 3 is observationally equivalent to equation 2 – so we cannot tell if we are estimating the demand relationship (as Giffen imagined) or if we are estimating a supply relationship. If Giffen were actually tracing a supply curve, rather than a demand curve, then it would be no surprise to find a positive price elasticity – most price elasticities of supply are positive. Looking at figure 2, it seems most plausible that Giffen has actually observed a supply curve, rather than a demand curve. Contemporaries were certainly aware of this potential confusion.[23]

[22] Lehfeldt, "Elasticity".
[23] Lehfeldt, "Economic cycles".

Figure 4. Movements in demand and supply curves.



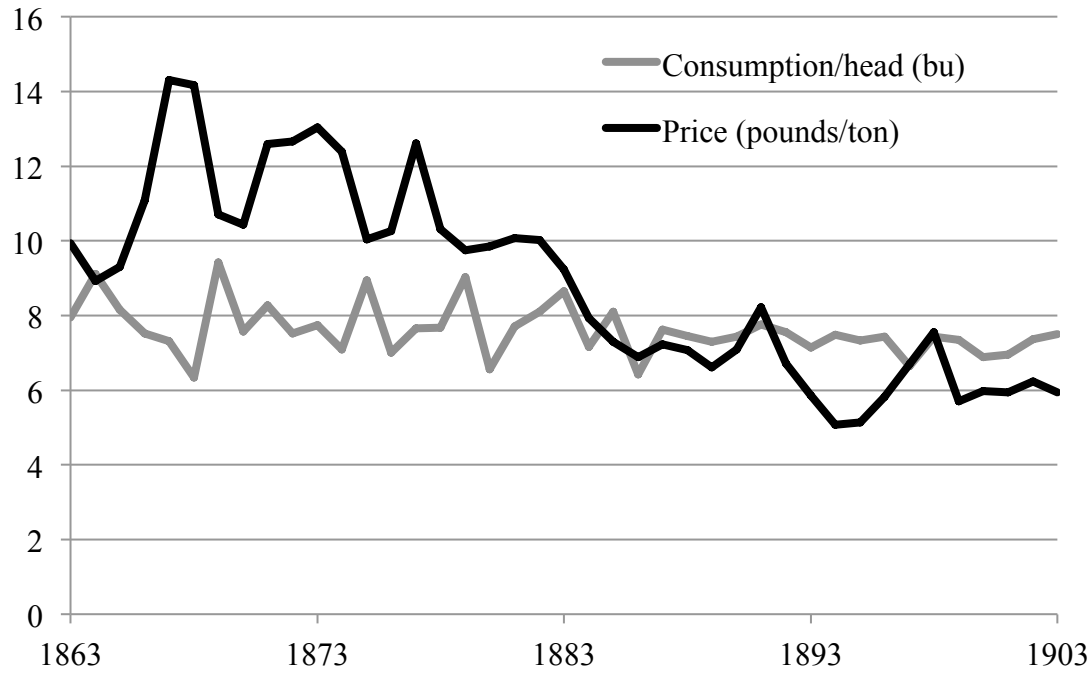
Of course, it is likely that both the demand and supply curves move each year. Then we are estimating some kind of "mongrel" equation that is a mixture of the demand and supply curves, and the loci of observed price-quantity pairs tells us nothing (directly) about elasticities. This is the classic problem of "identification". So how can we estimate the elasticities of demand? We can work with the demand equation directly but we have a problem of endogeneity. That is, since price determines quantity – and quantity determines price – we have a problem of two-way causation. This makes Ordinary Least Squares ("OLS") estimation invalid because it depends upon the assumption that causation flows *only* from the right hand side ("exogenous") variables to the left hand side ("endogenous") variable. When causation runs in both directions, the parameters estimated by OLS will be biased.

We generally solve this problem by using instrumental variables ("two-stage least squares"). We need to find variables ("instruments") that explain the price but are not affected by the quantity. We then use the instruments to construct a predicted series for the price. By construction, this predicted price series is not affected by the quantity series and causation can be running *only* from the (predicted) price to the quantity. The challenge is to find suitable instruments. In this case, it turns out to be straightforward. The English wheat price is determined by the wheat prices in the countries from which it imports – notably the USA and Russia – and the cost of shipping grain from those places. Notably, there was great technological change in shipping between 1853 and 1913 – such as the replacement of sail by steam and wooden ships by iron ships – and the cost of freight fell markedly. This is the kind of exogenous variation that we need to identify movements in the supply curve and hence the parameters in the demand equation (including the elasticity of demand).

Unfortunately, we will see below that endogeneity bias is *not* the source of error in Giffen's analysis – instrumenting for prices leaves the estimated price elasticity of demand completely unchanged.

The third pitfall is that the data that Giffen was looking at were all trending strongly downwards. In modern parlance, they are non-stationary. This is apparent in figure 5 below, where we plot the wheat price and per capita consumption over time. The downward trend in both series generates a positive correlation between them. However, look at the fluctuations – they are almost mirror images of one another. That is, consumption falls as price rises and vice versa. This is what we would expect to see from a normal good (i.e. wheat is clearly not a Giffen good – its price elasticity is negative). We will see that estimating the elasticity of demand, *controlling for non-stationarity in the data*, generates a standard, negative price elasticity that is statistically significant.

Figure 5. Wheat price and per capita consumption, 1863-1903.

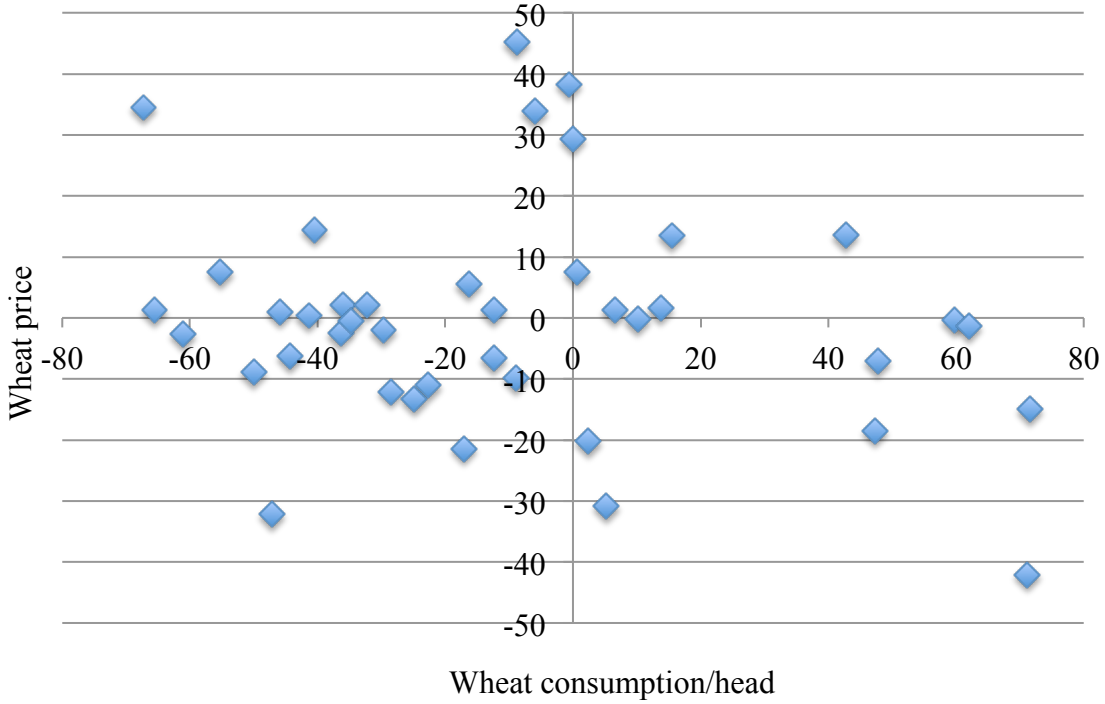


Sources: as in figure 1.

Could we have expected Giffen or Marshall to have done this? Clearly, economists and statisticians were not aware of non-stationarity around 1900 and, in that sense, it is no wonder that Giffen made his error. On the other hand, simple "ocular econometrics" (i.e. plotting the data) shows that the true price elasticity is negative. Plotting data was a standard approach around 1900, so we could certainly have expected Giffen to have noticed this point. Suppose that Giffen had simply detrended the data and plotted a scatter graph, analogous to figure 1 but now with (quasi-) stationary data. Then he would have seen figure 6 below. The correlation between consumption and price, for the period 1863-1903, is now -0.19 (p=0.25) – the exact reverse of what we found with figure 1. A regression of log consumption on log price would reveal an elasticity of -0.05;

we will see that this close to – and not significantly different from – our best estimate of the true elasticity, using a more sophisticated approach.

Figure 6. Detrended English wheat price and per capita consumption, 1863-1903.



I am now going to solidify the informal arguments made in this section with some data analysis. In table 1 below, I present the results of various regressions explaining wheat consumption per capita (hereafter, "consumption" always refer to consumption per capita). In model 1, I simply regress consumption on the wheat price. This is effectively what Lehfeldt was trying to do in 1914, and something that Giffen could done (or may, indeed, have actually done). This approach reveals a positive price elasticity, as Giffen noted.

Table 1. Estimating the price elasticity of demand for wheat, 1853-1913: part 1.

Explaining wheat consumption/head	Model 1 Coefficient OLS	Model 2 Coefficient OLS	Model 3 Coefficient OLS	Model 4 Coefficient OLS	Model 5 Coefficient IV
Constant	201.19*** (8.040)	182.40** (77.827)	3.737** (1.499)	6.408*** (0.532)	5.629*** (1.071)
Wheat price	0.006* (0.003)	0.003 (0.008)			
Income		-0.855** (0.272)			
Price level		0.986 (0.795)			
ln(Wheat price)			0.078 (0.069)		
ln(Income)			-0.263*** (0.088)		
ln(Price level)			0.481 (0.251)		
ln(Real wheat price)				0.014 (0.030)	0.073** (0.034)
ln(Real income)				-0.262*** (0.088)	-0.142 (0.137)
R^2	0.04	0.18	0.19	0.18	0.13
Adjusted R^2	0.03	0.14	0.15	0.15	0.09
F-statistic	2.73	4.34	4.57	6.33	2.99
SE of Equation	19.01	17.86	0.08	0.08	0.07
N	61	61	61	61	41

Notes: Standard errors in parenthesis. * and ** and *** indicate statistical significance at the 10, 5 and 1 per cent levels respectively. English wheat price is instrumented by: wheat prices in New York, Cincinnati, Indianapolis, Ithaca, San Francisco; wheat freight rates from Azov and Bombay; and the English CPI (excluding changes due to wheat price fluctuations). The r-squared of the first stage regression is 0.98 and the instruments are highly significant. Data are drawn from Jacks and Pendakur, "Global trade"; Jacks, "What drove nineteenth century commodity market integration"; and Jacks, "Intra- and international commodity market integration". Since the freight rate data begin in 1870, the number of observations is reduced.

In model 2, I regress consumption on a more complete demand function, additionally incorporating incomes and the price level (the consumer price index, or CPI). As is standard in this type of analysis, we proxy for income using the wage; this was the predominant source of income for the vast majority of consumers, and is measured much more accurately than total income, so is generally preferred. Note that I have adjusted the CPI to hold the price of wheat constant; this is very important in our analysis. In a standard exercise estimating a demand function, the researcher is interested in how the demand for a good changes in response to either a price change or an income change – where the income change can arise from any source (such as a change in labour market conditions). But the point about a Giffen good is that an increase in the price of the good itself *causes* both a substitution effect (generating lower consumption) and an *even larger income effect* (generating higher consumption overall). It is important for the analysis that the coefficient on the wheat price captures both the substitution effect *and* its income

effect. If the income effect of changes in the wheat price were subsumed in the overall income effect (caused by the variations in labour market conditions, for example) then it would be no surprise to find a negative wheat price effect (price elasticity). But this would not be a fair test of the Giffen Paradox. Hence the CPI is purged of changes in the wheat price, in order that all of the wheat price effect is captured by the estimated price elasticity of demand. Now, if wheat were a Giffen good then we would find a positive price elasticity, as Giffen proposed.

There are several points to note about the second regression. First, the estimated price elasticity does not change much and – most importantly – is still positive: the failure to incorporate income and the price level into his analysis was not the cause of Giffen's mistake. Second, the coefficient on income is negative and significant – i.e., as income rises, wheat consumption falls. Thus it appears that wheat was indeed an "inferior good" at this time, as we might expect: when workers became better off, they substituted away from wheat. (Remember: the conditions for being a Giffen good are stronger than those for being an inferior good. To be a Giffen good, it must be the case that increases in *price* have a perverse effect, generating such a large positive income effect on the quantity demanded that it outweighs the standard negative substitution effect.)

An inconvenience of running regressions with the raw data is that it is not obvious how to interpret the coefficients. It is standard to transform the variables by taking natural logarithms. One advantage of this procedure is that the coefficients on price and income can be interpreted directly as elasticities. The results of this transformation are reported in model 3. Note that the coefficient on the price level is one half. Economic theory suggests that it should be unity (prices should be "homogeneous of order zero") because this means that there is no money illusion in the economy. That is, if all prices and incomes doubled – due to inflation – then consumption decisions would remain unaltered. In fact, our coefficient on the price level is not statistically significantly different from unity. It is standard in these circumstances to impose the assumption of price homogeneity (by converting all the variables into real prices and incomes). The results of this transformation are reported in model 4. Again, it is clear that nothing substantive has changed and the estimated price elasticity of demand is still positive, *à la* Giffen.

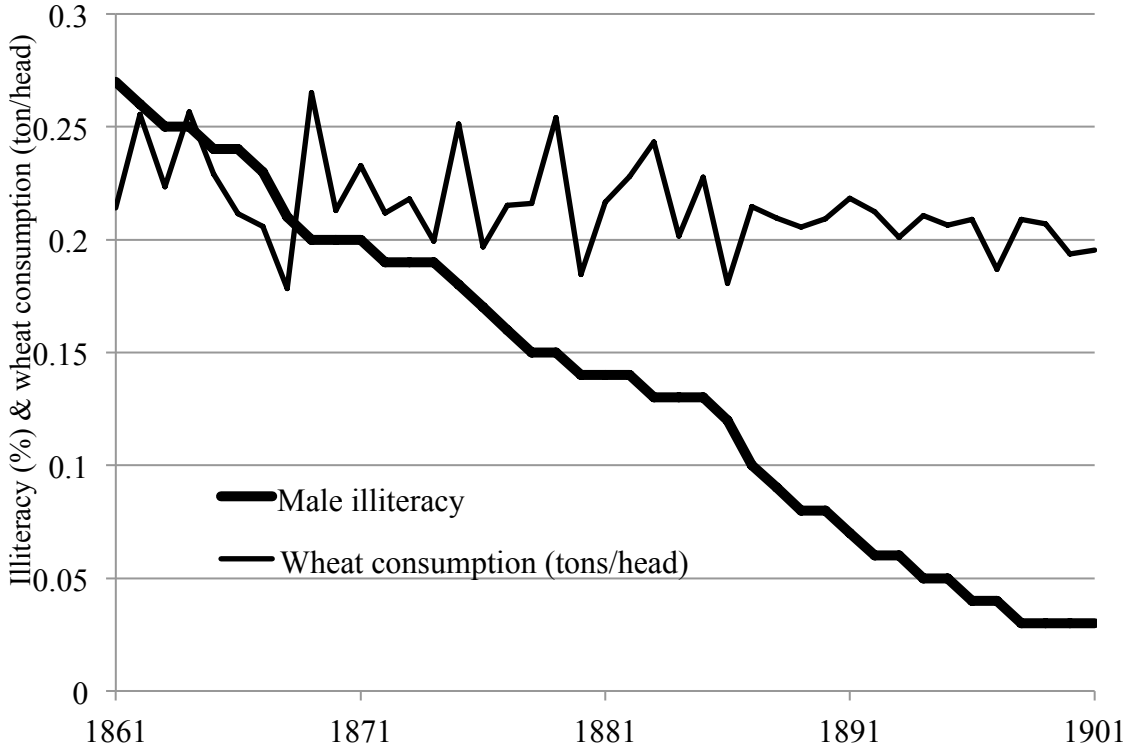
Model 5 takes account of the possible endogeneity of the wheat price. The model is not directly comparable to previous estimates because the sample size is reduced, owing to the fact that the data on the instruments begin only in 1870. But the coefficients are not drastically different from previous models (notably model 3) and the positive coefficient on the wheat price is now significant at the 6 per cent level. So Giffen's mistake does not stem from endogeneity bias. In fact, this is not surprising, even though wheat price and consumption are positively correlated. The important changes in shipping technology were pushing out the supply curve for wheat by lowering the cost of importing; these movements in the supply curve should trace out the demand curve nicely, just as Giffen would have hoped.

We now turn to the issue of non-stationarity. The analysis in this section is ordered slightly backwards – we have first rejected the simple explanations for Giffen's mistake and then worked up to the issue of stationarity. In fact, the first task of a modern applied economist, when analyzing time series data, is to check whether they are stationary. Valid inference can be drawn only once the data are stationary – whether that

be naturally, or through detrending or differencing. We have built up from a more basic analysis because it lies intellectually closer to Giffen's own starting point in the 1890s.

Almost universally, stationarity tests do not reject the hypothesis that the variables in this study are integrated of order one (they are I(1), in modern terminology).[24] It could be the case that wheat consumption per capita is trend-stationary; the test statistic is around the five percent critical value. It is not surprising that the data are I(1). First, it is likely on *a priori* grounds: economic theory tells us that prices, for example, generally follow a random walk – which makes them I(1). Second, it is obvious to the trained eye simply from graphing the data, as in figure 4 above. The question then arises as to how to best handle the data. It is well known that regressing one non-stationary data series on another will result in a spurious regression – typically finding a statistically significant relationship when really none exists. This is illustrated in figure 7 below, where we plot wheat consumption against English illiteracy rates. One might conclude obviously (and incorrectly) that illiterate people consume more farinaceous products and thus the decrease in illiteracy drove a decline in in wheat consumption. A regression model fits the data about as well as the models with prices and incomes (r-squared=0.17) and reveals a coefficient on illiteracy of 0.11 (significant at the one per cent level). Given that it is easy to generate such spurious regressions, how are we to employ the data to draw valid inferences?

Figure 7. Illiteracy rates and per capita wheat consumption in England, 1861-1901.



Sources: Wheat consumption, as in figure 1; male illiteracy rates drawn from http://www.bl.uk/collections/early/victorian/pr_intro.html.

[24] ADF test with five lags, testing against the null hypotheses of stationarity and trend stationarity.

The theory and estimation of demand equations is well developed in economics and has been widely applied. It would be very surprising if there were really no relationship between prices, incomes and wheat consumption in England in the late nineteenth century. In fact, if there is a true relationship between two (or more) integrated variables then we say that they are *cointegrated*. This means that a correctly formulated regression model incorporating the integrated variables will generate residuals that are stationary – even though none of the variables in the model are themselves stationary. The standard format for estimating such a relationship is the vector error correction model. The long run parameters for the wheat consumption VECM are reported in model 1 of table 2 below. As we would expect, the price elasticity of demand is significant and negative. Wheat was not a Giffen good – price increases reduced per capita consumption, rather than increasing it, as is clear from figure 4 above. Moreover, the income elasticity of demand was positive – wheat was a perfectly normal good. Giffen was merely led astray by the non-stationary nature of the data.

Table 2. Estimating the price elasticity of demand for wheat, 1853-1913: part 2.

Explaining wheat consumption/head	Model 1 Coefficient VECM	Model 2 Coefficient VECM	Model 3 Coefficient VECM	Model 4 Coefficient VECM (IV)
Constant	-5.275 (0.00)	-5.394 (0.00)	-4.961 (0.00)	-4.851 (0.00)
ln(Real wheat price)	-0.082*** (0.019)	-0.084*** (0.020)	-0.088*** (0.019)	-0.089*** (0.018)
ln(Real income)	0.124** (0.061)	0.154** (0.072)	0.071 (0.082)	0.047 (0.081)
R^2	0.74	0.75	0.75	0.74
N	59	49	40	40

Notes: Standard errors in parenthesis. * and ** and *** indicate statistical significance at the 10, 5 and 1 per cent levels respectively. English wheat price is instrumented by: wheat prices in New York, Cincinnati, Indianapolis, Ithaca, San Francisco; wheat freight rates from Azov and Bombay; and the English CPI (excluding changes due to wheat price fluctuations). The r-squared of the first stage regression is 0.98 and the instruments are highly significant. Data are drawn from Jacks and Pendakur, "Global trade"; Jacks, "What drove nineteenth century commodity market integration"; and Jacks, "Intra- and international commodity market integration". Since the freight rate data begin in 1870, the number of observations is reduced. All the data are integrated of order 1, but form a cointegrating vector.

Changing the period of estimation makes little or no difference. In particular, if we shorten the time horizon from 1913 to 1903 – the year in which Marshall gave evidence to the House of Commons – then the estimated equation is almost identical to the equation estimated over the complete period. This is demonstrated in model 2. Now, instead of shortening the time horizon by excluding post-1903 data, shorten it by excluding pre-1872 data. Then we get the results reported in model 3. This is a useful exercise for two reasons. First, Giffen certainly had access to the earlier data when he was formulating his ideas – even if that were as early as 1880, as discussed above. So if the relationship in the data were as strong in the early period as later on, then Giffen had less excuse for not noticing it. A comparison of models 1, 2 and 3 shows that the estimated elasticity of demand is unchanged over any of the time horizons. Second, it

seems sensible to instrument for wheat prices in the VECM, just as we did in the models that ignore stationarity, as a robustness check; I do this in model 4. The instruments are available only for the later years, and I wanted to facilitate a direct comparison between instrumented and uninstrumented equations. I do this by matching the time horizons of equations 3 and 4 (i.e. excluding the pre-1872 data). Note that it is not entirely clear how to instrument in a VECM; remarkably, nothing seems to have been written on this subject. So I approached the problem in a basic way by estimating the first stage (instrumenting) regression and then using the predicted values for wheat price in the second stage. In any case, instrumenting makes no difference and there is no evidence of reverse causation (in line with the earlier findings reported in table 1).

Thus the mystery of the missing Giffen good is solved. The reason that it is impossible to find Giffen goods is not that consumer behavior or demand conditions have changed so drastically since Giffen posed his original Paradox. Rather, he simply made a mistake and wheat was not, in fact, a Giffen good in the period in which he examined it. Although the Giffen good may live on forever as a theoretical possibility, it has never existed as an empirical reality.

5. How was Giffen's mistake propagated? The first accessory to Giffen's mistake was Marshall, when he introduced the notion of a Giffen good (although he did not use that term) into the third edition of his textbook in 1895. Marshall's *Principles of Economics* was the very first textbook in economics, and Marshall was probably the leading economist of his generation; thus the textbook went through many editions and was read by the many notable economists who followed him in the early twentieth century.[25] From the way in which the Giffen good is first introduced in the text, it sounds as if Marshall found it rather tedious – a bit like flagging an objection raised by some pernickety referee. After a lengthy discussion of the law of demand, Marshall notes:

"There are however some exceptions. For instance, as Mr Giffen has pointed out, a rise in the price of bread makes so large a drain on the resources of the poor.., they consume more, and not less of it. But such cases are rare; when they are met with they must be treated separately." Marshall, *Principles*, p. 208.

It is worth remembering that Giffen was a man of considerable importance.[26] As well as being Comptroller of Corn Returns, he was also President of the Royal Statistical Society (1882-4); he was a founder member of the International Statistical Institute (1885) and the Royal Economic Society (1890); he was knighted (1891) and made a Fellow of the Royal Society (1892); he was the second-ever recipient of the Guy Medal (in Gold) for Statistics (1894). One could imagine that Marshall would not want to upset Giffen and, after several promptings, introduced Giffen's Paradox into the third edition of his textbook. Later, Marshall seems to have taken the Giffen good to heart. We have seen that he mentioned it in his evidence to the House of Commons in 1903; and he defended it to Edgeworth in 1909, following Edgeworth's rather dismissive comments when reviewing Rea's book for the *Economic Journal*.

[25] Mason, *Robert Giffen*, 108-12.
[26] Mason, *Robert Giffen*, chapter 3.

The Giffen Paradox spread quickly to other countries. Already in 1897, it appeared in French in Pareto's *Cours d'Economie Politique*.[27]

"L'augmentation du prix d'une marchandise qui n'a pas de succédanés peut a pour effet immédiat d'en restreindre la consommation. L'augmentation du prix d'une marchandise qui a des succédanés peut, au contraire, avoir pour premier effet d'augmenter la consommation.

"Pour nous rendre compte de cet effet, en apparence paradoxal, considérons un exemple. L'alimentation constitue le principal chapitre du budget des classes pauvres. Supposons que des individus de ces classes se nourissent de viande, de pain et de pommes de terre. Le pain vient à augmenter de prix. Les individus considérés tâcheront de réduire les dépenses en dehors de l'alimentation, mais ils n'épargneront ainsi que fort de chose. La réduction devra s'étendre à l'alimentation elle-même, et ils devront renoncer à l'usage de la viande. Mais, par la même, ils se trouveront dans la nécessité de manger un plus grande quantité de pain. Le premier effet d'une hausse du prix aura donc été de faire augmenter la demande de pain."

The next major boost to the Giffen good seems to have come from Samuelson, when he produced a garbled account of it in the third edition of his own textbook, *Economics*:

"When the 1845 Irish famine greatly raised the price of potatoes, families who consumed a lot of potatoes merely because they were too poor to consume much meat might have ended up consuming *more* rather than less of the high-*P* potatoes. Why? Because now they had to spend so much on potatoes, the necessity of life, as to make it quite impossible to afford any meat at all and hence were forced to become even more dependent than before on potatoes. In brief, the substitution-effect was here overcome by the perverse income-effect applicable to a peculiar "inferior" good such as the potato, which tends to *decrease* in the poor man's budget when incomes rise. This *curiosum* is attributed to Sir Francis [sic.] Giffen, a Victorian economist." Samuelson, *Economics*, p. 432.

Samuelson cited this (false) example, even though Stigler had done his best to debunk it 17 years previously. Again, Samuelson's textbook was incredibly influential – being the standard text throughout the US for many years.

Since Samuelson, the Giffen good has been standard fare in all microeconomic textbooks. Economists love "completeness" – considering all the possible combinations and permutations. The Giffen good denotes a class of goods for which a positive income effect on quantity outweighs a negative substitution effect as the price rises. The fact that Giffen goods are never observed empirically is, in some sense, not relevant – the concept enables economists to complete the matrix of possible outcomes when prices change and consumers react. Thus the didactic role of Giffen goods is orthogonal to its empirical relevance.

[27] Pareto, *Cours*, vol. 2, 338.

6. Conclusion. There is virtually no evidence that Giffen goods exist, or ever have done; Jensen and Miller offer just a hint of Giffen behavior amongst a very restricted subset of Chinese consumers. In this paper, we have traced the history of the idea back to Giffen himself. We have reexamined the data that were available to him – per capita wheat consumption and prices in England in the second half of the nineteenth century. We have shown that – correctly interpreted – the data reveal that wheat was a normal good in that place and period. However, it is easy to see why Giffen interpreted the data incorrectly and believed that he had found paradoxical consumer behavior. And it is easy to see how Giffen's Paradox was successfully propagated, initially by Marshall and later by Walras and Samuelson. This is despite the scepticism of other contemporary economists, such as Edgeworth and Stigler. Probably the Giffen good will never die – it will persist in microeconomic textbooks for all eternity. Perhaps this is appropriate and useful as a didactic exercise. However, we should not leap from a theoretical *curiosum* (as Samuelson himself called it) to a supposition that it is empirically relevant.

Bibliography.

Board of Trade (1903), "Report on wholesale and retail prices in the United Kingdom in 1902, with comparative statistical tables for a series of years." British Parliamentary Papers, vol. X, xx-yy.

British Government (1878-9a), "Corn averages (memorandum respecting)," British Parliamentary Papers, vol. 65, 127-38.

British Government (1878-9b), "Corn (measures and weights)," British Parliamentary Papers, vol. 65, 139-96.

Brunt, Liam, and Edmund S. Cannon (2004), "The Irish grain trade from the Famine to the First World War," *Economic History Review*, vol. 57, 33-79.

Brunt, Liam, and Edmund S. Cannon (2013), "The truth, the whole truth and nothing but the truth: the English Corn Returns as a data source in economic history, 1770-1914," *European Review of Economic History*, vol. 17, 318-39.

Edgeworth, Francis Y (1909), "*Free trade in being*, by Russell Rea," *Economic Journal*, vol. 19, 102-6.

Feinstein, Charles H. (1995), "Changes in nominal wages, the cost of living and real wages in the United Kingdom over two centuries, 1780-1990," in Peter Scholliers and Vera Zamagni (eds.), *Labour's reward: real wages and economic change in nineteenth and twentieth century Europe* (Aldershot: E. Elgar, 1995).

Giffen, Sir Robert E. (1879), "The *Gazette* average prices of corn," *Journal of the Statistical Society,* vol. 42, 709-723.

Hall, Sir A. Daniel, *The Book of the Rothamsted Experiments* (London: J. Murray, 1905).

Howe, A. C. (2004), "Giffen, Sir Robert (1837–1910)," *Oxford Dictionary of National Biography* (Oxford: University Press).

Jacks, David S. and Krishna Pendakur (2010), "Global trade and the maritime transport revolution," *Review of Economics and Statistics,* vol. 92, 745-755.

Jacks, David S. (2006), "What drove nineteenth century commodity market integration?" *Explorations in Economic History*, vol. 43, 383-412.

Jacks, David S. (2005), "Intra- and international commodity market integration in the

Atlantic economy, 1800-1913," *Explorations in Economic History*, vol. 42, 381-413.
Jensen, Robert T., and Nolan H. Miller (2008), "Giffen behavior and subsistence consumption," *American Economic Review*, vol. 98, 1553-77.
Koenker, Roger (1977), "Was bread Giffen? The demand for bread in England circa 1790," *Review of Economics and Statistics*, vol. 59, 225-9.
Kohli, Urlich (1986), "Robert Giffen and Irish potato: Note," *American Economic Review*, vol. 76, 539-42.
Lawes, J. Bennet, and J. H. Gilbert, "Report of experiments on the growth of wheat for 20 years in succession on the same land," *Journal of the Royal Agricultural Society of England* (1864), vol. 25, 93-185.
Lawes, J. Bennet, and J. H. Gilbert, "On the continuous growth of wheat on the experimental plots at Rothamsted during the 20 years, 1864-83, inclusive," *Journal of the Royal Agricultural Society of England* (1884), vol. 20, 391-481.
Lehfeldt, R. A. (1914), "The elasticity of demand for wheat," *Economic Journal*, vol. 24, 212-17.
Lehfeldt, R. A. (1915), "*Economic cycles: their law and cause*, by A. L. Moore," *Economic Journal*, vol. 25, 409-11.
Logan, Trevon, and Paul Rhode (2010), "Movable feasts: a new approach to endogenizing tastes," unpub. mimeo., Ohio State University, Dept. of Economics.
Marshall, Sir Alfred (1895), *Principles of economics* (3rd edition, London: MacMillan).
Marshall, Sir Alfred (1908), "Memorandum on the fiscal policy of international trade," British Parliamentary Papers, vol. X, xx-yy.
Marshall, Sir Alfred (1925), *Memorials of Alfred Marshall*, edited by A. C. Pigou (London: MacMillan).
Mitchell, Brian R. (1962), *Abstract of British historical statistics* (Cambridge: University Press).
Mason, Roger S. (1989), *Robert Giffen and the Giffen Paradox* (Totowa: Barnes & Noble).
Pareto, Vilfredo (1897), *Le cours d'économie politique* (Lausanne: Librairie de l'Université).
Rea, Russell (1908), *Free trade in being* (London: MacMillan).
Read, Charles (2013), "Giffen behavior in Irish Famine markets: an empirical study," *Cambridge Working Paper in Economic and Social History*, no. 15.
Samuelson, Paul A. (1964), *Economics: an introductory analysis* (New York: McGraw Hill).
Spencer, Hamish G. (2004), "Fisher, Sir Ronald Aylmer (1890–1962)," *Oxford Dictionary of National Biography* (Oxford: University Press).
Stigler, George J. (1947), "Notes on the history of the Giffen Paradox," *Journal of Political Economy*, vol. 55, 152-6.
Young, Arthur (1770), *A six months' tour through the north of England* (London: W. Strahan).