The Window Tax: A Case Study in Excess Burden[†]

Wallace E. Oates and Robert M. Schwab

"The adage 'free as air' has become obsolete by Act of Parliament. Neither air nor light have been free since the imposition of the window-tax. We are obliged to pay for what nature lavishly supplies to all, at so much per window per year; and the poor who cannot afford the expense are stinted in two of the most urgent necessities of life."

— Charles Dickens (1850, p. 461)

The window tax provides a dramatic and transparent historical example of the potential distorting effects of taxation. Imposed in England in 1696, the tax—a kind of predecessor of the modern property tax—was levied on dwellings with the tax liability based on the number of windows. The tax led to efforts to reduce tax bills through such measures as the boarding up of windows and the construction of houses with very few windows. Sometimes whole floors of houses were windowless. In spite of the pernicious health and aesthetic effects and despite widespread protests, the tax persisted for over a century and a half: it was finally repealed in 1851.

Our purpose in this paper is threefold. First, we provide a brief history of the tax with a discussion of its rationale, its role in the British fiscal system, and its economic and political ramifications. Second, we have assembled a dataset from microfilms of local tax records during this period that indicate the numbers of

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windows in individual dwellings. Drawing on these data, we are able to test some basic hypotheses concerning the effect of the tax on the number of windows and to calculate an admittedly rough measure of the excess burden associated with the window tax. Third, we have in mind a pedagogical objective. The concept of excess burden (or "deadweight loss") is for economists part of the meat and potatoes of tax analysis. But to the laity the notion is actually rather arcane; public-finance economists often have some difficulty, for example, in explaining to taxpayers the welfare costs of tax-induced distortions in resource allocation. The window tax is a textbook example of how a tax can have serious adverse side effects on social welfare.[1] In addition to its objectionable consequences for tax equity, the window tax resulted in obvious and costly misallocations of resources.

A Brief History of the Window Tax

The window tax was introduced in England in 1696 by King William III.[2] Burdened with expenses from the Revolution, the war with France, and the costs of re-coinage necessitated by the "miserable state" of existing coins, which had been reduced by "clipping" (the scraping-off of small portions of the high-grade silver coins), the King levied a new tax consisting originally of a flat rate of 2 shillings upon each house and an additional charge of 4 shillings upon houses with between 10 and 20 windows and 8 shillings upon houses with more than 20 windows (Dowell 1965, vol. 3, p. 168). The tax was intended to be a temporary levy, but it was restructured and increased several times. In the end, the window tax lasted in various forms for over 150 years; as we noted above, it was not repealed until 1851.

An important feature of the tax was that it was levied on the occupant, not the owner of the dwelling. Thus, the renter, not the landlord, paid the tax. However, large tenement buildings in the cities, each with several apartments, were an exception. They were charged as single residences with the tax liability resting on the landlord. This led to especially wretched conditions for the poor in the cities, as landlords blocked up windows and constructed tenements without adequate light and ventilation (Glantz 2008, p. 33).

Although the rate structure of the window tax was revised numerous times over this lengthy period, one feature is of special importance for our study. The tax did not consist of a series of smoothly rising marginal rates but instead included a series of "notches"—points at which an additional window brought with it a large

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[1] And in fact, several textbooks offer the window tax as an example of a tax that distorts economic decisions. See, for example, Stiglitz (1988, p. 17), Mateer and Coppock (2014, p. 201), and Rosen and Gayer (2010, p. 369).

[2] This section draws heavily on Glantz (2008), who provides by far the most careful and thorough treatment of the history of the window tax. For other treatments of the tax, see Ward (1952), Beckett (1985), and Dowell (1965, vol. 3, pp. 168–192; first published in 1884). For useful histories of taxation in the United Kingdom that cover this period and address the window tax, see Sinclair (1803), Dowell (1884, vol. 3), Kennedy (1913), Binney (1958), and Douglas (1999).

increase in tax liability. Consider, for example, the reforms introduced in 1747, under which Parliament raised and recast the rate structure of the tax. The fixed 2 shillings per dwelling was detached from the window tax and imposed in addition to a new schedule of rates of windows. Under the new rate schedule, there was a tax of 6 pence *on every window* in a house with 10 to 14 windows, of 9 pence per window in houses with 15 to 19 windows, and of 1 shilling for every window in houses with more than 20 windows.[3] As a result, we might expect to find, for example, many more houses with 9, rather than 10, windows. We will make use of these notches in our later empirical study of the effects of the tax.

The window tax, incidentally, had an antecedent: the hearth tax. Imposed in 1662 by Charles II after the Restoration, the hearth tax consisted of a levy of 2 shillings for every fire-hearth and stove in houses in England and Wales. The tax was very unpopular in part because of the intrusive character of the assessment process. The "chimney-men" (as the assessors and tax collectors were called) had to enter the house to count the number of hearths and stoves, and there was great resentment against this invasion of the sanctity of the home. The window tax, in contrast, did not require access to the interior of the dwelling: the "window peepers" could count windows from the outside, thus simplifying the assessment procedure and obviating the need for an invasion of the interior.

Both of these taxes were intended to be a visible indicator of ability to pay. As pointed out in a discussion in the House of Commons (1850) just prior to the repeal of the window tax, "The window tax, when first laid on, was not intended as a window tax, but as a property tax, as a house was considered a safe criterion of the value of a man's property, and the windows were only assumed as the index of the value of houses." But as Adam Smith (1776 [1937], p. 798) observed in *The Wealth of Nations*, the number of windows could be a very poor measure of the value of a dwelling: "A house of ten pounds rent in the country may have more windows than a house of five hundred pounds rent in London; and though the inhabitant of the former is likely to be a much poorer man than that of the latter, yet so far as his contribution is regulated by the window-tax, he must contribute more to the support of the state."

Although the window tax removed the need for tax assessors to enter the house to count the number of hearths, the tax created some administrative problems of its own—not the least of which was the definition of a "window" for purposes of taxation. In 1848, for example, Professor Scholefield of Cambridge paid tax on a hole in the wall of his coal cellar (House of Commons 1848). In the same year, Mr. Gregory Gragoe of Westminster paid tax for a trapdoor to his cellar (House of Commons 1848). An individual might have to pay tax should a brick fall out of the wall if the hole admitted light into the house. Indeed, if the dwelling was already at one of the "notch" points for the tax, a new hole from a missing brick could force the resident to pay a higher rate on every window in the house. This issue was a source of considerable unrest

[3] There were 20 shillings to the pound and 12 pence to the shilling. The average annual income during this period was a bit less than 20 pounds per year.

among taxpayers. As late as 1850, there were continued requests to the Chancellor of the Exchequer for clarifications on the definition of a window.

The schedule and levels of rates for the window tax were amended (in some cases raised dramatically) over the life of the tax. As mentioned earlier, the original rate structure in 1696 was recast in 1747. Then in 1761, a tax rate of 1 shilling per window was established for homes with 8 or 9 windows and rates were raised on homes with 10 or more windows. We look at the effect of the 1761 tax rate changes in a later section of the paper.

Significant changes continued to be made before the tax was eventually repealed. In 1784, Prime Minister William Pitt increased tax rates to compensate for lower taxes on tea. In response, "Owners in both town and country began to disfigure their houses . . . by blocking up their windows" (House of Commons 1848). In 1797, Pitt's Triple Assessment Act tripled the window tax rates to help pay for the Napoleonic Wars. The day following this new Act, thousands of windows were blocked up, and "Lighten our darkness we beseech thee, O Pitt!" was written in chalk on the blocked-up spaces (House of Commons 1848). There were some reductions in the window tax after 1820.

There were some exemptions under the window tax. Various factories and buildings were exempted from the tax: public offices, farm houses that cost less than 200 pounds per year, dairies, cheese rooms, malt houses, granaries, and coach makers. The rationale for these exemptions was either of two conditions: the windows provided air rather than light, or the trade required ample light so that workshops had to have glass windows. In addition, officials exempted some residences under various pretexts. Some exceptions were made for certain wealthy parties. In some instances, the presence of serious disease resulted in tax exemption. As stated in a decree in 1819, "In cases where the terror of contagion had forced the wretched inhabitants to restore the windows, and admit the light and air, the tax so incurred should be remitted" (House of Commons 1819). Such exemptions were a source of considerable controversy.

England and Scotland were both subject to the window tax, but Ireland was exempted because of its impoverished state. Some members of Parliament joked: "In advocating the extension of the window-tax to Ireland, the hon. Gentleman seemed to forget the fact that an English window and an Irish window were very different things. In England, the window was intended to let the light in; but in Ireland the use of a window was to let the smoke out" (House of Commons 1819).

The Adverse Health and Aesthetic Effects of the Window Tax

Much of the controversy over the window tax involved its highly regressive incidence, and the tax did indeed burden the poor.[4] However, the distorting effects

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[4] In Appendix G to his *Principles of Economics*, Alfred Marshall (1890 [1948]) discusses the window tax in a footnote. Like Smith, his concern is solely with the incidence of the tax (not with its effects

on resource allocation were perhaps even more widespread and profound. Residents throughout England and Scotland boarded up windows to avoid the tax.[5] In 1848, Mr. Byers, the president of the Carpenters' Society in London, reported to Parliament that nearly every house on Compton Street in Soho had employed him to reduce the number of windows (House of Commons 1848). In many houses, bricks took the place of previously existing windows. Moreover, newly constructed dwellings economized in drastic ways on the number of windows. In at least one apartment building in Edinburgh, the entire second floor (containing bedrooms) had no windows at all. Of course, there are some instances in which residents by design had numerous windows as a means of displaying their wealth.

The most serious adverse effect of the window tax was on human health. A series of studies by physicians and others found that the unsanitary conditions resulting from the lack of proper ventilation and fresh air encouraged the propagation of numerous diseases such as dysentery, gangrene, and typhus. In one instance in 1781, a typhus epidemic killed many citizens in Carlisle. Dr. John Heysham traced the origins of the outbreak to a house inhabited by six poor families (Guthrie 1867, p. 409), and described the dwelling in this way:

> In order to reduce the window tax, every window that even poverty could dispense with was built up, and all source of ventilation were thus removed. The smell in this house was overpowering, and offensive to an unbearable extent. There is no evidence that the fever was imported into this house, but it was propagated from it to other parts of town, and 52 of the inhabitants were killed.[6]

A series of petitions to Parliament resulted in the designation of commissioners and committees to study the problems of the window tax in the first half of the 19th century. In 1846, medical officers petitioned Parliament for the abolition of the window tax, pronouncing it to be "most injurious to the health, welfare, property, and industry of the poor, and of the community at large" (House of Commons 1850). Indeed, when Parliament acknowledged the serious damage to public health

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on behavior). However, unlike Smith, Marshall speaks approvingly of the tax as a measure of ability-to-pay, arguing that the number of windows provides a reasonable index of "the scale and style of household expenditure in general" (p. 802). He contends: "If the part of the tax assessed on houses were removed, and the deficit made up by taxes assessed on the furniture and indoor servants, the true incidence of the taxes would be nearly the same as now" (p. 802). Marshall, along with Adam Smith in the passage quoted earlier in the text, fails to address the quite striking effects of such taxes on efforts to avoid their payment.

[5] There are many references to the window tax in English literature. In the 1748 novel *Tom Jones,* for example, one of Henry Fielding's characters exclaims (p. 380): "Why now there is above forty Shillings for Window-lights, and yet we have stopped up all we could; we have almost blinded the house I am sure . . ."

[6] One reviewer of this paper suggests that this opinion by a 19th century physician needs to be taken "with a grain of salt." This may be true, but as we note, there was widespread recognition of the injurious health effects of the window tax.

resulting from the blocking of windows, this ultimately resulted in the repeal of the tax in 1851.

Conceptual Framework

A tax system creates a "notch" if a small change in behavior leads to a discrete change in both average and marginal tax rates. As we noted above, the window tax incorporated notches throughout much of its history. Consider, for example, the tax schedule over the 1747–1757 period. As we showed above, a person who owned a home with 9 or fewer windows paid no tax. But his neighbor whose home had 10 windows would pay a tax of 6 pence *for each window.* Consequently, for the neighbor, the marginal tax rate for the 10th window was 60 pence (which is equal to 5 shillings) while the average tax rate for the 10 windows was 6 pence.

Notches are uncommon and have received relatively little attention in the literature on taxation (for an excellent overview of notches, see Slemrod 2010). "Kinks" are far more common. A tax system creates a kink if a small change in behavior leads to a discrete change in the marginal tax rate but just a very small change in the average rate. The United States federal individual income tax, for example, has several kinks. Earning an additional dollar could move a taxpayer into the next higher tax bracket, thus raising the marginal tax rate with (almost) no effect on the average tax rate. For an empirical study of bunching at kink points under the US income tax, see Saez (2010).

Public finance economists often argue against notches on the grounds that they lead to large deadweight losses: that is, a tax schedule with notches provides strong incentives for taxpayers to distort behavior and locate at a notch.[7] We explore this argument as we develop a conceptual framework to think about the window tax.
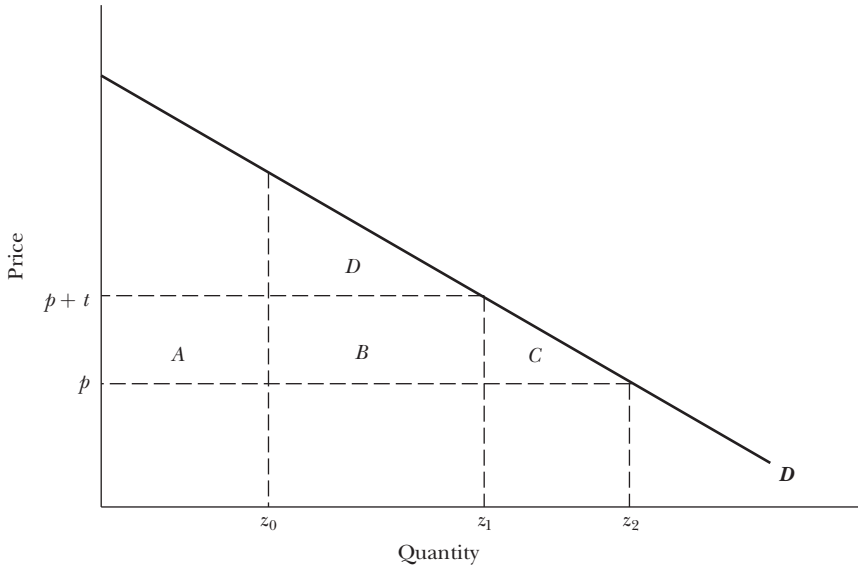
Consider a simple window tax that includes just one notch. Consumers pay no tax if they own z_0 or fewer windows but pay a tax of t pence per window if they own more than z_0 windows. In looking at Figure 1, there will be three cases to consider. Case I consists of consumers who would own fewer than z_0 windows in the absence of the tax. Case I consumers continue to own the same number of windows after the window tax is put in place. Thus, Case I consumers pay no tax and suffer no deadweight loss.

Case II consumers purchased more than z_0 windows before the tax and continue to purchase more than z_0 windows after the tax is imposed (though fewer windows than they did initially unless demand is perfectly inelastic). Figure 1 shows

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[7] Blinder and Rosen (1985), however, argue that in some important cases, tax and subsidy plans with notches should at least be considered as serious contenders when public policy seeks to encourage or discourage some activity.

Figure 1
Demand for Windows and a Window Tax with a Single Notch

Notes: Consider a simple window tax that includes just one notch. Consumers pay no tax if they own z_0 or fewer windows but pay a tax of t pence per window if they own more than z_0 windows. Case I includes consumers who would own fewer than z_0 windows in the absence of the tax. Case I consumers pay no tax and suffer no deadweight loss. Case II consumers purchased more than z_0 windows before the tax and continue to purchase more than z_0 windows after the tax is imposed. They pay a total tax bill of $A + B$, suffer a welfare loss of $A + B + C$, and thus incur a deadweight loss of C. Case III includes consumers who would buy more than z_0 windows if there were no tax, but exactly z_0 once the tax is imposed. These consumers pay zero tax and suffer a welfare loss of $D + B + C$. Aside from Case I consumers, the decision on whether to pay the tax turns on the relative sizes of area D and area A.

the impact of the window tax on Case II consumers.[8] This consumer purchases z_2 windows at the market price p but z_1 windows once the tax is imposed. The notch is irrelevant for Case II consumers. For them, the window tax is equivalent to a standard excise tax of t pence per window. They pay a total tax bill of $A + B$, suffer a welfare loss of $A + B + C$, and thus incur a deadweight loss of C.[9]

Case III includes consumers who would buy more than z_0 windows if there were no tax, but exactly z_0 once the tax is imposed. These consumers pay zero tax. The tax has, however, distorted their decisions and so they suffer a deadweight loss.

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[8] Formally, welfare losses should be calculated from the compensated (Hicksian) demand curve rather than the ordinary (Marshallian) demand curve. In practice, this distinction rarely turns out to be very important.

[9] In general, deadweight loss depends on both supply and demand. There is an implicit assumption throughout this paper that the supply curve for windows is perfectly elastic.

A Case III consumer owns $z_2 - z_0$ fewer windows as a result of the tax. Before the tax, the consumer realized consumer surplus of $D + B + C$ from those windows (the difference between willingness to pay and price), and so a Case III consumer suffers a welfare loss of $D + B + C$.

Which consumers fall into Case II, those who choose to pay the tax, and which into Case III, those who avoid the tax by restricting their consumption of windows? Case II consumers suffer a loss of $A + B + C$; Case III consumers suffer a loss of $D + B + C$. Consumers will choose the option that minimizes their loss from the tax. And so we come to the following rule: Consumers will choose to pay the tax (Case II) if $A + B + C < D + B + C$. They will avoid the tax (Case III) if $A + B + C > D + B + C$. They will be indifferent if $A + B + C = D + B + C$.

Subtracting $B + C$ from both sides shows that the key here is the relative magnitudes of areas A and D in Figure 1. The intuition behind this result is as follows. A consumer could choose to pay the tax and therefore purchase an additional $z_1 - z_0$ windows. The benefit from paying the tax is the difference between willingness to pay for windows and the price of a window (including the tax) integrated over $z_1 - z_0$ windows, area D. But in order to be able to purchase these $z_1 - z_0$ windows, the consumer must pay the tax on the first z_0 windows, area A. So the decision on whether or not to pay the tax turns on whether the benefit from purchasing additional windows (area D) is greater than, less than, or equal to the cost (area A).

This analysis suggests how to test the hypothesis that the window tax distorted people's decisions. If the window tax distorted decisions, then we should find "too many" people at the notches.[10] We present such a test in the next section of the paper.

How the Window Tax Distorted Decisions

To explore the quantitative impact of the window tax on actual behavior, we assembled a dataset from local tax records in 18th and 19th century Britain that indicates the number of windows per household over the period 1747 to 1830. We describe the dataset, and how we went about pulling it together, in the online Data Appendix to the paper available with this paper at http://e-jep.org.

We focus initially on the observations in our dataset from 1747 to 1757. As we discussed above, the window tax was unchanged over this period and included three notches. A homeowner in this period paid no tax if the house had fewer than 10 windows; a tax of 6 pence per window if the house had 10–14 windows; a tax of 9 pence per window if the home had 15–19 windows; or a tax of 1 shilling per

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[10] More specifically, the test we outline here is a test of a sufficient condition that the tax distorted decisions. It is possible that if the notches were set so low that everyone purchased more windows than the number of untaxed windows, no one falls in Case III. The tax, in this example, would still distort decisions since the tax would have the same impact as a standard excise tax.

window if the home had 20 or more windows. (In addition, each homeowner paid a fixed duty of 2 shillings. This house tax was separated from the window tax in 1747.) Thus the marginal and average tax rate jumped sharply when a consumer installed the 10th, 15th, or 20th window.

We have tax data on 496 homes during this period. Most of the observations in our dataset are from Ludlow, a market town in Shropshire. Ludlow is close to the border with Wales. It had a population of roughly 4,000 people at the start of the nineteenth century; its current population is 10,500. We have data for two or more years for roughly 60 percent of the houses in our sample and for just a single year for the remaining 40 percent. We have treated our data as a cross section. In those cases where the number of windows changed over the 11-year period, we used the last observation available. We want to capture the effect of the tax, and using the last observation for each home gives us the greatest opportunity to observe a home-owner's response to the window tax.

The period from 1747–1757 is a particularly useful sample for our purposes. As Glantz (2008) explains, the administration of the window tax proved to be an ongoing, difficult problem. It was common for homeowners to camouflage or board up windows until the tax collector was gone. Homeowners and local surveyors often avoided the window tax by taking advantage of loopholes and ambiguities in the tax code. The tax was imposed on every window in inhabited houses, while all industrial or retail buildings and homes of low-income families were exempt. Homeowners frequently attempted to disguise regular living quarters by storing a few sacks of grain in a room. Bribery and corruption among tax assessors was common.

As a result, tax collections were often much lower than expected. Parliament revised the window tax in 1747 to deal with these problems, and included heavy fines for attempts to evade the tax. As part of the 1747 act, "The practice of blocking up windows in order to evade assessment and subsequently reopening them, was prohibited under a penalty of 20s for every window reopened without due notice given to the tax surveyor" (Glantz 2008, pp. 8–9). These penalties were steep: a fine of 20 shillings is 20–40 times as large as the tax on windows itself. The 1747 revisions also included a number of provisions that improved the administration of the tax.

The 1747 act apparently was able to reduce tax evasion significantly. Data from the 1747–1757 period are therefore likely to yield a reasonable estimate of the actual number of windows. Data from earlier periods are more likely to reflect often successful efforts to evade the tax and therefore understate the actual number of windows.[11]

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[11] In fact, some studies in other contexts have interpreted a large data value at a key cutoff as evidence of corruption. Stigler (1986, cited in Duggan and Levitt 2002), for example, showed that the height distribution among French males based on measurements taken at conscription was normally distributed except for a shortage of men measuring 1.57–1.597 meters (roughly 5 feet 2 inches to 5 feet 3 inches) and an excess number of men below 1.57 meters. Not coincidentally, the minimum height for conscription into the Imperial army was 1.57 meters.

Figure 2
**Distribution of Number of Windows, 1747–1757 Sample**
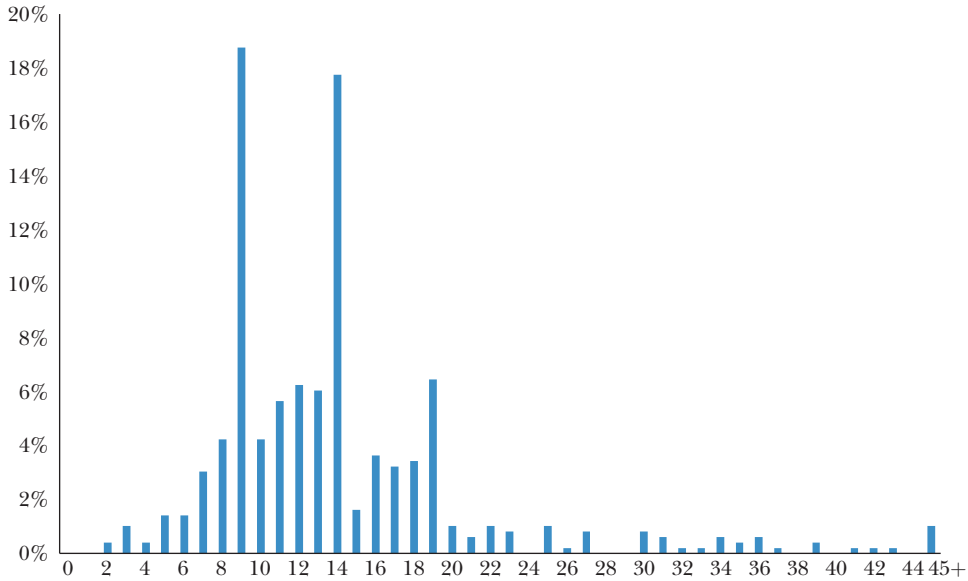
If the window tax distorted behavior, then we should expect to see "too many" homes with 9, 14, or 19 windows. This in fact is exactly what we find. Figure 2 presents a histogram showing the number of windows for homes in our sample. The pattern here is clear. There are sharp spikes in the number of homes at all three notches.[12] At the first notch, 18.8 percent of the homes have 9 windows, while 4.2 percent have 8 windows and 4.2 percent have 10 windows; at the second notch, 17.7 percent have 14 windows, while 6.0 percent have 13 windows and 1.6 percent have 15 windows; and at the third notch, 6.5 percent have 19 windows, while 3.4 percent have 18 windows and 1.0 percent have 20 windows.

Recall that the 1761 revisions to the window tax established a tax rate of 1 shilling per window on houses with 8 or 9 windows; from 1747 until 1760, only houses with 10 or more windows were subject to the tax. This change suggests a second test of the hypothesis that the window tax distorted people's decisions. We should expect to find "too many" houses with 7 windows beginning in 1761 but not in periods before 1761.

We collected a sample of 170 houses from the period 1761–1765 (there were significant changes to the tax rate in 1766). The houses in this second sample are from Wiltshire and Hampshire in southwest England. Figure 3 shows the distribution

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[12] We present some straightforward statistical tests of the results in this section in the online Appendix available with this paper at http://e-jep.org.

Figure 3
Distribution of Number of Windows, 1761–65 Sample
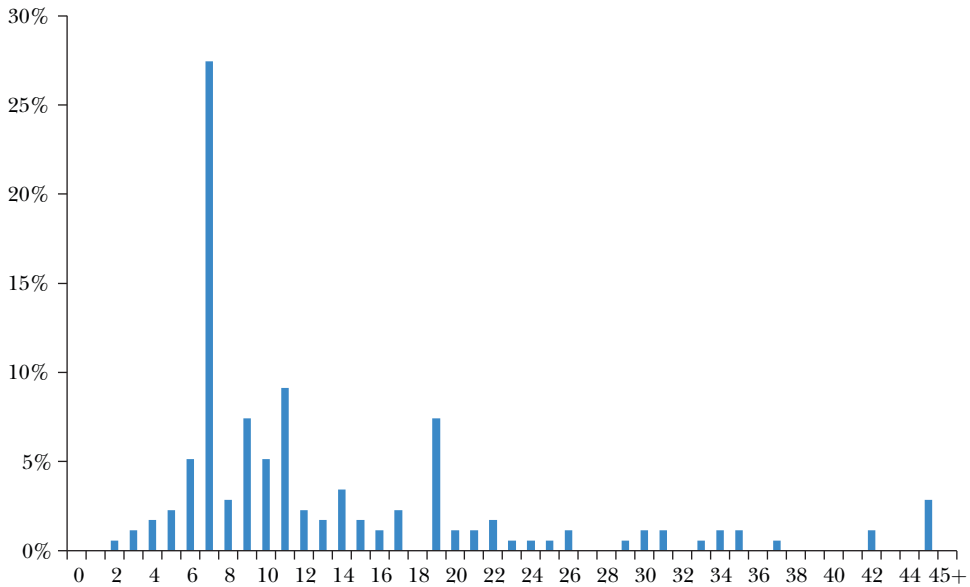
of the number of windows for the homes in our 1761–1765 sample. We find a very large spike at 7 windows. In this sample, 27.4 percent of the houses have 7 windows but just 5.1 percent have six and just 2.9 percent have 8. In sharp contrast, just 3.0 percent of the houses in our 1747–1757 sample had 7 windows.

We also find concentrations in our 1761–65 sample at 11 windows (9.1 percent) and 19 windows (7.4 percent). This is consistent with 1761–65 tax policy; there were notches at both 11 and 19 windows during this period. In summary, the evidence from both samples is consistent with the hypothesis that property owners' decisions were distorted by the window tax. Our finding is in keeping with the observations of the prominent British historian M. Dorothy George (1926, p. 77), who noted: "When the duty was increased in 1710 it became a universal practice to stop up lights. How increasingly general the practice became may be gathered from the fact that in 1766 when the tax was extended to houses with 7 windows and upwards, the number of houses in England and Wales having exactly 7 windows was reduced by nearly two-thirds."

How Large Was the Deadweight Loss from the Window Tax?

We use a simulation model to develop a rough estimate of the deadweight loss from the window tax. We certainly would not claim that our simple model is able to

capture all elements of tax policy in mid-18th century England. We would, however, argue that the model offers a sensible estimate of the order of magnitude of the efficiency cost of the tax.

We summarize the basic structure of the model here and present a more detailed discussion in the online Appendix. There are 1,000 consumers in the simulation. The price elasticity of demand is the same for all of the consumers but the height of their demand curves varies to reflect differences in incomes, tastes, and other determinants of the demand. The simulation first solves for the demand for windows in the absence of the tax. Each of the 1,000 consumers calculates consumer surplus (willingness to pay minus expenditure) if they were to buy 0, 1, 2, . . . 60 windows and chooses the number of windows that maximizes their consumer surplus. We then re-run the model under a tax policy that is similar to the 1747–1757 window tax. Consumers in our model who own 9 or fewer windows pay no tax; those who own 10–14 windows pay a tax of 6 pence per window; and those who own 15 or more windows pay a tax of 9 pence per window.[13] Each consumer in the model re-optimizes given this tax policy. The model captures each consumer's demand for windows with and without the tax; consumer surplus with and without the tax; and taxes paid.

We searched for values of the important parameters of the model that yield results that correspond most closely to our 1747–1757 data. Our estimated price elasticity of demand for windows is .149 (and so, for example, a 10 percent increase in the price of windows would reduce the demand for windows by 1.49 percent). We do not have any evidence against which we can evaluate this estimate. This estimate may seem low, but it is important to note that the demand for windows may be slow to adjust to a change in tax policy since the stock of new houses is small compared to the stock of existing houses (though as we argued above, many homeowners responded to the tax by blocking up existing windows).

The magnitude of the price elasticity has some interesting implications for our estimate of the deadweight loss from the window tax.[14] Recall our earlier discussion of consumers who do not locate at a notch (Case II) and those who do (Case III). We argued that the cost of locating at a notch is the difference between willingness to pay for windows and the price of a window (excluding the tax) integrated over the windows a consumer foregoes by choosing the notch. When demand is inelastic and so the demand curve is steep, willingness to pay rises quickly as the quantity of windows falls. Therefore, if demand is inelastic, it is costly to choose to locate at a notch and so we should expect to find fewer consumers at a notch.

Figure 4 is helpful in seeing this result when demand is linear. Suppose consumers pay no tax for the first z_0 windows and a tax of t pence per window on all windows above z_0. If demand is relatively elastic (and so the relevant demand curve

[13] The tax policy we looked at in the simulation did not include the third notch that existed under the 1747–1757 tax (consumers with homes with 20 or more windows paid 1 shilling per window). Only 11 percent of the homes in our sample have 20 or more windows.
[14] We thank David Autor for his very helpful suggestions for this section of the paper.

Figure 4
Deadweight Loss from a Quantity Restriction
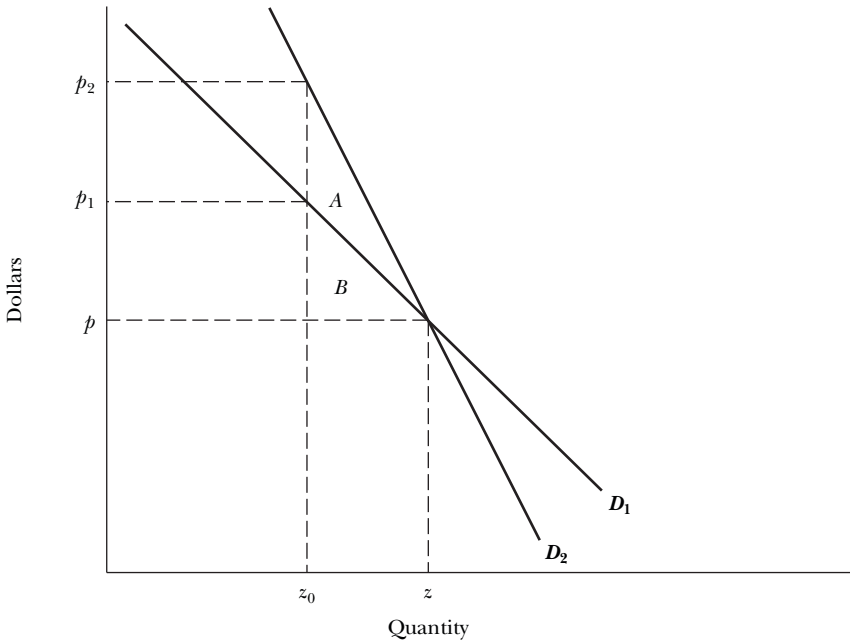
is D_1), choosing z_0 windows will lead to a deadweight loss of B. But if demand is relatively inelastic (and so the relevant demand curve is D_2), choosing z_0 windows leads to much larger deadweight loss of $A + B$.[15]

Figure 4 also suggests that the losses for consumers who do choose a notch—what we have called Case III—are large when demand is inelastic. For those consumers, the window tax is a quantity distortion. As Oates (1997) explains, the welfare loss from a policy that distorts quantity directly is large when demand is inelastic and small when demand is elastic; in the limit, the loss from a constraint on quantity is zero when demand is perfectly elastic. The intuition here is that where demand is less responsive, a consumer's valuation of marginal units rises quickly as we move away from the optimum.

The losses for consumers who do not locate at a notch—what we have called Case II—is straightforward. For this group, the window tax is a standard excise tax. The deadweight loss from an excise tax is small when the elasticity of demand is small. In the limit, the deadweight loss will be zero if demand is perfectly inelastic (because in that case a consumer's decision will be unaffected by the tax).

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[15] Neary and Roberts (1980) would call p_1 or p_2 the shadow price of a window. A shadow price in this context is the price of a window that would lead a consumer to purchase z_0 windows in the absence of the quantity restriction.
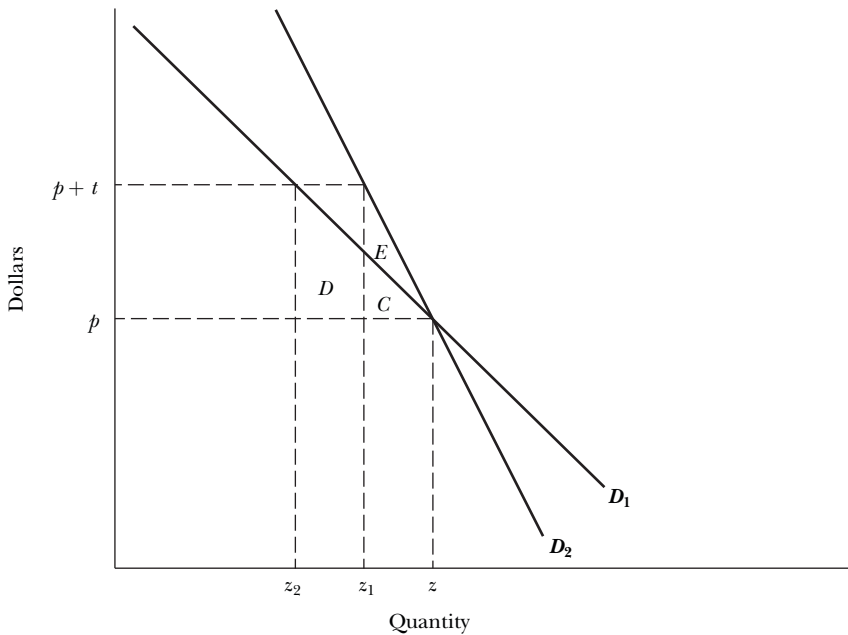
Figure 5
Deadweight Loss from a Tax

Figure 5 makes this point clear in the simple case where demand is linear. Demand curve D_1 is more elastic than demand curve D_2. A tax of t pence per window leads to a deadweight loss of $D + C$ if demand is elastic but just $E + C$ if demand is inelastic; to see this, note that $D + C$ equals $(t/2)(z - z_1)$ and $E + C$ equals $(t/2)$ $(z - z_2)$.

This argument is similar in some ways to the Weitzman (1974) analysis of price and quantity instruments in environmental policy. In that paper he shows that a quantity instrument such as cap and trade is equivalent to a price instrument such as a Pigovian tax if the marginal abatement cost of pollution is known. Weitzman then considers the case where the marginal abatement cost is uncertain and, as a consequence, actual abatement costs turn out to be different from the regulator's estimate of abatement costs when either the regulatory price or quantity was chosen. He shows that the welfare effects of these two alternative instruments depend on the relative slopes of the marginal benefit curve from abatement and the marginal abatement cost curve. In particular, Weitzman argues that in the uncertainty case, a price instrument is more efficient than a quantity instrument when the marginal-benefit-of-abatement curve is relatively flat but that a quantity instrument is more efficient if the marginal benefit curve is relatively steep. As in our case of the window tax, the relationship between the slope of the demand curve (that is, the marginal benefit curve) and the magnitude of a distortion is different for price and quantity instruments.

Table 1
Simulation Results and 1747–1757 Data

	Simulation	*1747–1757 data*
Share of houses with 9 windows	21.9%	18.8%
Share of houses with 14 windows	13.3%	17.7%
Mean number of windows	14.1	14.1

Table 1 shows the actual and simulated values for the percentage of homes with exactly 9 windows, the percentage of homes with exactly 14 windows, and the mean number of windows. As that table shows, we were able to replicate the key features of our 1747–1757 data fairly closely. In the simulation, 21.9 percent of the homes had 9 windows, 13.3 percent had 14 windows, and the average number of windows is 14.1. In our 1747–1757, sample 18.8 percent had 9 windows, 17.7 percent had 14 windows, and the average home had 14.1 windows.

The window tax has a significant effect on the demand for windows in the simulation. None of the consumers in the simulation chose 10, 11, 15, or 16 windows when faced with the 1747–1757 window tax; it is never optimal to buy at a notch. The tax reduces average demand from an estimated 16.2 windows in the absence of the tax to an estimated 14.1 windows.

We focus initially on the consumers in the simulation who chose one of the notches. As we noted above, 21.9 percent of the households in the simulation chose 9 windows when faced with our version of the 1747–1757 tax schedule. This includes 5.5 percent of the sample that also chose 9 windows in the absence of the tax and whose choices were therefore not distorted. Thus 16.4 percent of the simulated households chose 9 windows under the tax, but more than 9 windows in the absence of the tax. All of the households that chose 14 windows when faced with the tax chose more than 14 windows in a world without the window taxes. And so in total, 29.7 percent of the households in the simulation chose one of the notches in direct response to the window tax.

How large is the distortion from the window tax? The estimated losses were very large for the households at one of the two notches. We find that for those consumers the deadweight loss equaled 62 percent of the taxes those consumers paid. That is to say, for every dollar collected the simulated version of the window tax imposed an additional burden of 62 cents on the households at the notches (over and above the direct burden of the tax paid). The excess burden, not surprisingly, is particularly large for households that chose 9 windows. Those consumers paid zero in window tax, and so for them the entire burden of the tax is excess burden.

We now turn to the entire sample of 1,000 simulated households. There are a number of alternative ways to think about the excess burden of a tax. We could focus on *total* excess burden as a fraction of *total* tax. In our simulation,

the deadweight loss from the window tax is 13.4 percent of tax revenues. Alternatively, we might focus on the marginal excess burden of the window tax, which is a common measure of the distortionary effect of a tax. It is defined as the *marginal* excess burden from a *marginal* increase in tax revenue. We have calculated the marginal excess burden of the window tax by increasing the tax rates by 10 percent in the model and then calculating the resulting change in deadweight loss divided by the change in tax. We find a marginal excess burden of .23—raising an additional $1 of tax revenue through the window tax would generate an additional $0.23 of excess burden.

Concluding Remarks

The window tax provides a clear illustration of the deadweight loss from taxation. The discussion of deadweight loss can sometimes become a tangled debate over the measurement of Harberger triangles, partial versus general equilibrium estimates, and so on. Here is a clear case in which we mean what we say when we talk about excess burden. The window tax led many people to live in very dark houses and in environments that had significant, pernicious effects on their health.

The window tax is thus a quite striking example of a tax that led to radical tax-avoiding behavior with high associated levels of excess burden. This raises a further, intriguing question that goes beyond the scope of this paper but is worthy of mention here. If the window tax was a bad tax that generated such adverse effects and intense criticism, why did it persist over such a lengthy period? In fact, the rates were raised, in some instances quite dramatically.

The answer to this question requires a broader consideration of the political and fiscal issues of the times. But these were years of intense fiscal pressures, involving at various junctures massive military expenditures. The monarch and Parliament resorted in several instances not just to increases in the land and window taxes, but to a range of new taxes on various commodities and the introduction of an income tax (Dowell 1884, vol. 2). Thus, continued use of the window tax was, in part at least, a response to a setting of extreme budgetary tightness in which the government perceived little room for reduction in any tax rates. Perhaps the lesson here is that when governments need to raise significant revenue, even a very bad tax can survive for a very long time.

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