DEPICTING DEADWEIGHT LOSS FROM IMPERFECT INFORMATION

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Abstract

The concept of deadweight loss is used by introductory microeconomic textbooks to convey the social welfare consequences of many market failures and distortions. But while the market model is used to reveal the deadweight loss from externalities, market power, taxes, tariffs, and even public goods, it is not employed to illustrate the deadweight loss from imperfect information. This paper advances a way to relate imperfect information's effect on social welfare by showing the deadweight loss it causes within the standard supply and demand framework.

Keywords: asymmetric information, deadweight loss, imperfect information, lemons, market failure

JEL Classification: A22

Introduction

This paper advances a new model that illustrates the social welfare consequences of imperfect information by capturing the associated deadweight loss. Introductory microeconomic textbooks currently do not present such a model despite leaning heavily on the concept of deadweight loss to convey the social welfare effects of two other market failures, i.e., externalities and monopoly power. Explanations of both hinge on market diagrams that depict their negative impact on economic surplus (*aka* total surplus). For example, see Acemoglu *et al*. (2022), Bade and Parkin (2021), Cowen and Tabarrok (2021), Frank *et al*. (2022), Hubbard and O'Brien (2020), Mankiw (2021), and Mateer and Coppock (2021).

The deadweight loss due to the market failure inherent in the market for a public good can also be illustrated with a market diagram. This is accomplished by generating society's demand for the public good as the vertical summation of its individuals' demands (*aka* marginal value curves) instead of as the horizontal summation of individuals' demands as done with a private good (e.g., see Acemoglu, *et al*., 2022; Case, *et al.*, 2020; Hubbard and O'Brien, 2020). The intersection of the public good's demand and supply curves identifies the quantity that is "efficient" because it maximizes economic surplus. The total amount of a public good provided – by the government, philanthropists, and individuals who are not deterred by free-riders – that is either less or more than that efficient quantity results in easily identifiable deadweight loss on the market diagram. Thus, imperfect information is the one major market failure whose detrimental welfare effects have not been expressed with the help of a familiar market diagram where deadweight loss is plainly illustrated.

A common approach in introductory microeconomic textbooks' examinations of externalities, market power, and public goods is not just to address the welfare effects of those

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market failures using the concept of deadweight loss, but to then follow up with discussions of the possible benefits and hazards of government policies that are advanced to reduce the ill-effects of those market failures. It is notable that imperfect information is also the only major market failure which microeconomic textbooks present without dependably considering the potential for government regulatory policies to correct for it (e.g., Arnold, 2019; Bade and Parkin, 2021; Case *et al.,* 2020; Frank *et al.,* 2022; Hubbard and O'Brien, 2020; Mankiw, 2021; and McConnell *et al.,* 2021 all acknowledge the problem of imperfect or asymmetric information without mentioning how governments often react by imposing regulations). This omission is odd given the volume of government regulations regarding the quality of goods and services exchanged in markets, where the purported objective of the regulations is to reduce imperfect information by assuring that the purchased items are both safe and what they claim to be. The US Government regulates most of the items a typical American household purchases, including foods, drugs, housewares, tools, and professional services (such as plumbing, food preparation, legal services, and health care) to protect people from uninformed purchases.

Textbooks tend to rely on mere descriptions of particular markets to develop insights into the problem of buyers and/or sellers lacking important knowledge about a good or service being sold. For example, many textbooks characterize the used car market (i.e., the market for "lemons" discussed by Akerlof, 1970) and/or insurance markets. Although common for textbooks to overlook the practice of many governments to ostensibly reduce imperfect information using regulations, a few proceed to the topics of screening and signaling in which market participants take actions that reduce the asymmetric information without government involvement (e.g., see Bade and Parkin, 2021; Case *et al.,* 2020; and Mankiw, 2021). For example, used car buyers can screen the used car by having a mechanic inspect it.[2]

This paper advances a model that depicts the deadweight loss caused by types of imperfect information where screening and signaling do not satisfactorily forestall its welfare costs and, therefore, government regulations are often implemented. The model's capturing of the deadweight loss from this variety of imperfect information reveals the potential welfare benefits of regulations that would eliminate the imperfect information. Of course, the costs of overseeing regulations plus the potential welfare costs of poorly designed regulations and of regulatory capture must also be considered when examining the net expected benefits of such regulations.

Market analyses that show deadweight loss are very familiar to economics majors by the time they reach the topic of imperfect information. Not only will they have likely worked with the concept of deadweight loss when discussing externalities and market power, most will have used it to analyze the welfare effects of taxes and tariffs (e.g., see Acemoglu *et al.,* 2022; Arnold, 2019; Cowen and Tabarrok, 2021; Hubbard and O'Brien, 2020; Mankiw, 2021; Mateer and Coppock, 2021) and possibly of price ceilings and price floors (e.g., see Arnold, 2019; Cowen and Tabarrok, 2021). Having deadweight loss diagrams support discussions of the welfare effects of these economic phenomena undoubtedly aids many students' efforts to understand them. It is reasonable to expect many of those students to appreciate a corresponding diagram that illustrates the welfare costs of the form of imperfect information that has led to so many government regulations.

The deadweight loss from imperfect information is a little complicated because it has both demand and supply effects, but, fortunately, those effects are additive and easily combined.

[2] There are "lemon laws" in which the government protects the buyers of new cars and used cars that are still under warrantee. The bulk of used-car sales are not subject to lemon laws.

The consequences of imperfect information are analyzed in this paper by first considering its effect on demand before isolating its effect on supply and, then, simply combining the two effects to present the complete impact on a market. The effect on a market's demand is simple and the effect on its supply is straightforward. Both would be accessible to economics students who had previously understood the deadweight losses associated with externalities as well as with the market power of a monopolist. Combining the analyses may seem to be more complicated than the sum of their parts, and some educators may prefer to let the two aspects be illustrated separately rather than jointly. The special case of Akerlof's (1970) market for lemons can be depicted with a couple of small tweaks of the model, which are presented in the Appendix.

The Deadweight Loss from Consumers' Uncertainty about a Good's Quality

First imagine that all widgets produced are quality widgets and that all consumers know they are quality widgets. The supply curve for these quality widgets is labeled S in Figure 1 and the demand curve would be the curve labeled D. Consumers' knowledge of the widgets' quality means that D directly reflects society's marginal valuation of the widgets. Under these circumstances the efficient quantity (that maximizes economic surplus) would be Q* and the equilibrium market price would be P*. The consumer surplus would be composed of the areas **a + b + c**, and producer surplus would be **d + e + f + g**, so economic surplus would be their sum (see Table 1).

Now suppose that consumers become concerned that a subset of the widgets sold are not quality widgets but counterfeit widgets that will prove to be worthless after being purchased. This uncertainty (or imperfect information) regarding the quality of any particular widget for sale will decrease the demand for widgets (e.g., to the demand curve D′ in Figure 1) with a greater probability of buying a counterfeit widget causing a greater reduction in demand due to the reduced expected marginal value of purchased widgets. In this initial step of the analysis of imperfect information it is assumed that – although consumers believe that there is some positive probability that a widget they buy could be a counterfeit – there are actually no counterfeit widgets so that all widgets for sale are quality widgets. Yet the decrease in demand will reduce the quantity sold to Q′ and the equilibrium price to P′.

The consumer surplus will now be the sum of areas **a + b + d + e**. Note that while the market demand curve (i.e., D′) shifted in, the marginal value remains represented by D, so that consumer surplus includes areas **b + e**. Producer surplus is simply area **g**. Accordingly, economic surplus is now **a + b + d + e + g**. Table 1 shows the deadweight loss from the introduction of consumer doubts to be the economic surplus that is lost, i.e., **c + f**. Of course, such a misreading of the situation by consumers would be corrected by sufficient observations that no counterfeit widgets are produced which would return the demand to D.

Figure 1. Deadweight Loss Due to Consumer Doubts.

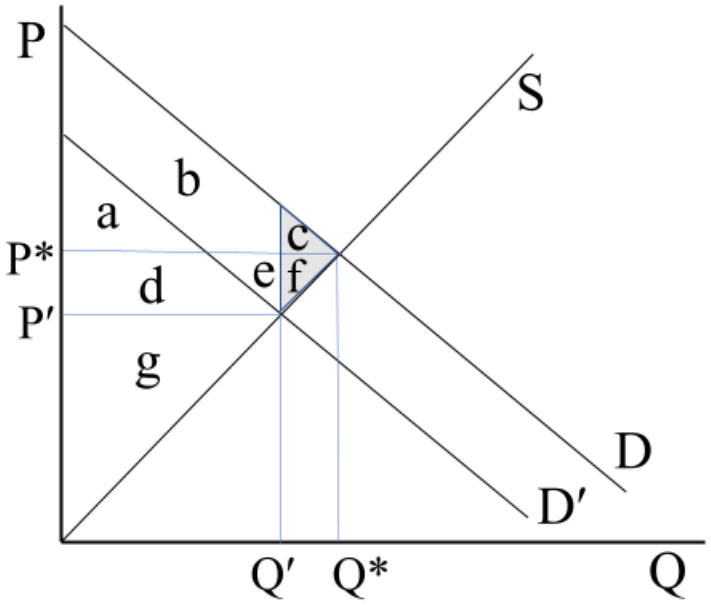

Table 1. Welfare Analysis Results from Figure 1.

	Consumers Confident in Quality (so that Demand = D)	Consumers Doubt Quality (so that Demand =D′)	Loss due to Consumer Doubts
Consumer Surplus	a + b + c	a + b + d + e	c – (d + e)
Producer Surplus	d + e + f + g	g	(d + e + f)
Economic surplus	a + b + c + d + e + f + g	a + b + d + e + g	(c + f) (= deadweight loss)

The Deadweight Loss when Credible Counterfeit Goods are Also Supplied

Now assume there are not just suppliers of quality widgets, but there are also producers of low-quality widgets, i.e., they sell something that buyers cannot distinguish from the quality widgets at the time of purchase, but which will later be revealed to be low-quality counterfeits. To simplify the initial analysis, begin by assuming the extreme case in which the low-quality widgets are sham widgets that provide no value to their consumers. The possibility of the low-quality widgets offering some value will be considered further below.

Figure 2 implicitly represents the supply of these credible counterfeit widgets by specifying the supply of quality widgets (S_{QUAL}) as well as the total supply of widgets (S_{TOT})

which includes both the supplies of quality widgets and counterfeit widgets: The supply of credible counterfeit widgets (S_{CC}) is the horizontal difference between S_{QUAL} and S_{TOT}. Although S_{TOT} is composed of two very different types of goods, prospective buyers are unable to tell them apart until after the purchase.

Figure 2. Deadweight Loss Due to Unknown Counterfeit Goods

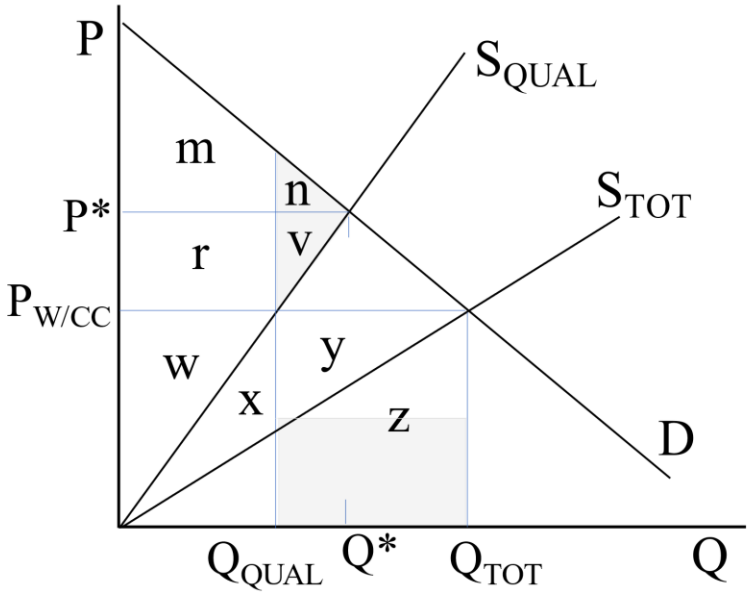

Table 2. Welfare Analysis Results from Figure 2.

	No Credible Counterfeits so that $S = S_{QUAL}$	w/ Credible Counterfeits so that $S = S_{TOT}$	Loss Due to Credible Counterfeits
Consumer Surplus	m + n	m + r – (y + z)	(n + y + z) – r
Producer Surplus	r + v + w	w + x + y	(r + v) – (x + y)
Economic surplus	m + n + r + v + w	m + r + w + x – z	(n + v + z) – x (= deadweight loss)

To highlight the effects of having two indistinguishable qualities of widgets supplied, this section will work under the assumption that those demanding (quality) widgets are oblivious to the possibility that they could buy a counterfeit widget. This demand for quality widgets by the unsuspecting consumers is represented by D in Figure 2. Note that this demand curve also

represents the expected marginal value curve since there are no concerns about the quality of widgets that reduce the demand as occurred in the previous section. But the actual – if unexpected – existence of counterfeit widgets means that the relevant market supply includes the supply of those widgets. Figure 2 reveals the equilibrium that would prevail in this case at the intersection of D and S_{TOT} where the equilibrium price is $P_{w/CC}$ and the equilibrium quantity exchanged is Q_{TOT}. The quantity of *quality* widgets produced and sold is Q_{QUAL}, which means that the quantity of credible counterfeit widgets sold is (Q_{TOT}– Q_{QUAL}).

Note that the efficient quantity of widgets is Q*, which can be found on Figure 2 directly below where the D and S_{QUAL} curves intersect, is where the marginal value of quality widgets equals the marginal cost of quality widgets. This quantity would occur *if* there were no counterfeit widgets being produced that are indistinguishable from quality widgets. One can also see the equilibrium price (P*) that would prevail in the absence of the counterfeit widgets to the left of the intersection of the same two curves on Figure 2. The consumer, producer, and economic surpluses that would exist in this case are shown in Table 2. In this case, consumer surplus would be **m + n** and producer surplus would be **r + v + w**, making economic surplus **m + n + r + v + w**.

Understanding the social welfare effects of imperfect information from both quality and counterfeit widgets being sold requires differentiating between the two kinds of widgets. Figure 2 also shows (and Table 2 reports) that the consumer surplus when counterfeit widgets are present is composed of areas **m + r** as well as the *loss* of areas **y + z** because that is how much consumers spend on worthless, sham widgets. The producer surplus has area **w** from the production of quality widgets as well as areas **x + y** from the production of the counterfeit widgets. This all adds up to an economic surplus of **m + r + w + x** minus **z. (**This analysis assesses the *ex post* welfare effects of the imperfect information as opposed to the expected social welfare, which differ because of consumers' mistaken belief that all widgets sold will be quality widgets. More complete analysis which also accommodates consumers' learning the share of the widgets sold that are counterfeit will be provided in the next section.)

The final column of Table 2 reports how the introduction of credible counterfeit widgets causes consumer surplus to fall by **n** (since the sale of quality widgets has dropped), to increase by **r** (since the price of quality widgets has dropped), and decrease by areas **y + z** (since they capture the amount spent by consumers on sham widgets). It also shows that producer surplus falls by **r + v** (since the producers of quality widgets are selling less and at the lower price of $P_{w/CC}$), while rising by **x + y** because of the producer surplus gained from the production and sale of the counterfeit widgets. That is, **x + y** represents the profits that motivate producers to supply the sham widgets. If it can be assumed that the supply curves are all straight lines, then the formula for the area of a triangle (i.e., area = ½ [base]×[height]) can be employed to show that the producer surplus gained from the production of the counterfeit widgets (= triangle **x + y**) is equal to half of what the consumers' lose by buying the worthless widgets (= rectangle **y + z**).

The deadweight loss from the existence of credible counterfeit widgets is the loss of economic surplus of **n + v + z** minus **x** (as reported in the lower-right corner of Table 2) and can be summarized as taking two forms. First, the decrease in market price from the added supply of credible counterfeit widgets causes less quality widgets to be produced (from Q* to Q_{QUAL}). The corresponding deadweight loss can be seen in Figure 2 as areas **n + v** (lightly shaded in Figure 2). Second, the production of counterfeit widgets causes more negative consumer surplus due to consumers' wasted spending (i.e., the loss of **y + z**) than it adds to producer surplus (**x + y**). This constitutes additional deadweight loss given that area **z** is unambiguously larger than area **x**

(since **y + z** is unambiguously larger than **x + y**).[3] If it is assumed that **x + y** is half the size of **y + z** as discussed above, then the corresponding deadweight loss would be half of **y + z** (which is also lightly shaded in Figure 2).

There are four simplifying assumptions in this analysis that should be disclosed despite none of them compromising the intuitions regarding social welfare that the model conveys. These assumptions are:

1) Figure 2 considers the best-case scenario in which the minimum possible level of deadweight loss exists by implicitly having the buyers who assign greater value to quality widgets be the ones who acquire them. Accordingly, it is assumed that those who derive the least consumer surplus from a quality widget end up purchasing counterfeit widgets. An alternative figure that specified S_{CC} first and then horizontally added S_{QUAL} to form S_{TOT} would show the opposite occurring so that lost consumer surplus would be its greatest feasible amount (while the producer surpluses would not be different). If the amount of consumer surplus a buyer would receive from a quality widget were to be uncorrelated with the quality of widget they acquire then the total deadweight loss would be somewhere between the two extremes. (This same simplifying assumption is made with the usual welfare analysis of a binding price ceiling, in which the accompanying diagram assumes that those who receive the scarce goods are the ones who value them the most. A flipped, yet analogous compromise is made with welfare analysis of a binding price floor which has the producers who can attain the greatest producer surplus from sales of the goods somehow doing so.)

2) The above analysis assumes that the good is either of full quality or a worthless sham, but it could be that the low-quality goods provide positive utility less than that of quality goods. And each of the lesser widgets could all have the same quality, or their quality could vary between full quality and being worthless. A greater average quality of the counterfeits would reduce the negative consumer surplus caused by the counterfeits (i.e., cause it to be less than the sum of areas **y + z**) and, therefore, reduce the deadweight loss.

3) The analysis assumes there are no welfare consequences in the form of consumers' disappointment or regret from unknowingly purchasing low-quality widgets, but any disappointment or regret would constitute a loss to be added to consumers' pecuniary loss from paying more for a widget than it is valued.

[3] The payment of **y + z** by consumers to the producers of counterfeit widgets (that are assumed in this particular analysis to be completely worthless) could be interpreted as a transfer from consumers to producers since nothing of value is exchanged in return for the money. But it is assumed that there are production costs to the worthless widgets so that those producers only profit by **x + y** as opposed to their total revenue of **y + z**. Paying for the resources to produce the counterfeit widgets is just as much a social cost as the production costs of quality widgets (since they both represent the opportunity cost to society of production). Since the resources wasted in the production of goods that have no social value are caused by the presence of the unexpected counterfeit widgets, they need to be included as part of the deadweight loss resulting from the imperfect information. This explains why (**y + z**) – (**x + y**), or (**z – x**), is included as deadweight loss. This deadweight loss caused by imperfect information that gives rise to the counterfeit goods is similar to the deadweight loss from subsidies which cause more goods to be produced at a greater cost to society than their social value. The Appendix explores the special case of the used car market where there are no production costs (since used cars are not directly produced), in which case the characterization of the payment from consumers to the sellers of worthless counterfeits as a transfer is more accurate.

4) As maintained at the beginning of this section, the analysis assumes that the buyers are completely naïve about the possibility that they might purchase a counterfeit widget. The next section will combine the demand effects of consumers being aware of possible low-quality widgets (discussed in the last section) with the effects just presented from the existence of both quality and counterfeit goods.

Before continuing it is wise to acknowledge that while the inability of consumers to detect lower quality goods as just discussed qualifies as imperfect information, imperfect information would also constitute asymmetric information if the producers of the counterfeit widgets were fully aware that they are peddling merchandise of a lesser quality. Interestingly, that would not have any effect on the above analysis since being aware that the goods they are producing are substandard would not alter their behavior as long as they obey incentives to maximize profits.

The Deadweight Loss from Imperfect Information

A complete analysis of the impact of the imperfect information (or asymmetric information) characterized above on a market is now conducted by recognizing how the presence of poor-quality counterfeit goods affect both consumers' demand and the quantity supplied of quality goods. As mentioned previously, this only requires a straightforward combination of the two effects presented in the previous two sections.

Figure 3 depicts the pure demand for widgets (D) that would prevail without doubts about the quality of the widgets and, therefore, represents the marginal value of widgets. The figure then shows the *expected* marginal value of widgets (i.e., D′) where the distance between D and D′ is a positive function of the probability that a purchased widget will be counterfeit. Figure 3 also depicts the total supply of widgets as the horizontal sum of the supply of quality widgets and the supply of credible counterfeit widgets (i.e., $S_{TOT} = S_{QUAL} + S_{CC}$) as done in the previous section. Note that the figure shows that the share of quality widgets produced would be the same at any price. This constant share is an artifact of both S_{QUAL} and S_{CC} being straight lines from the origin. The share of quality widgets (as depicted in Figure 3) is roughly two-thirds, which is due to the S_{QUAL} being flatter than the S_{CC} and reveals a dependably lower marginal cost of the n^{th} quality widget than of the n^{th} counterfeit widget. More generally, the particular marginal costs of the quality and counterfeit goods dictate the shares of each good at each price which determines the probability of purchasing a counterfeit good, where that probability is needed to determine the expected marginal value at each price and, therefore, how much D′ differs from D.

Figure 3. Deadweight Loss Due to Imperfect Information.

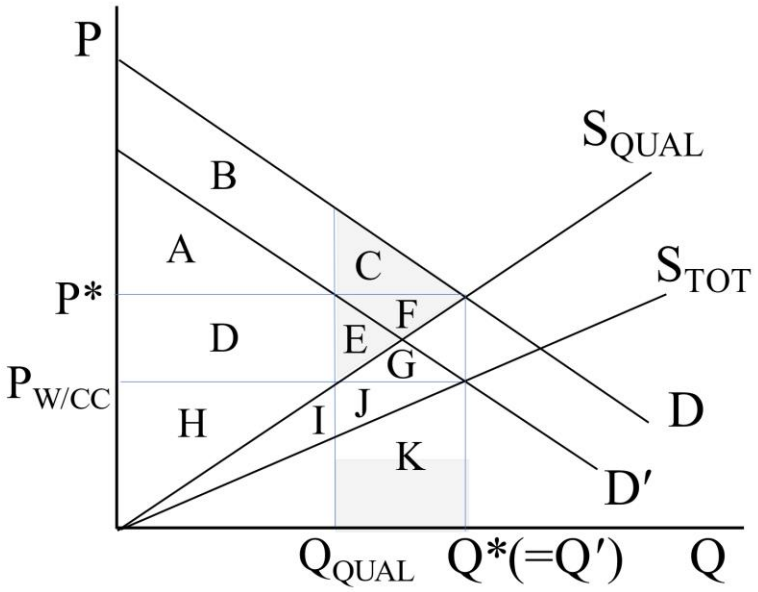

Table 3. Welfare Analysis Results from Figure 3.

	No Credible Counterfeits so that D = D & S = S_{QUAL}	w/ Credible Counterfeits so that D = D′ & S = S_{TOT}	Loss Due to Credible Counterfeits
Consumer Surplus	A+B+C	A+B+D – (J+K)	(C+J+K) – D
Producer Surplus	D+E+F+H	H+I+J	(D+E+F) – (I+J)
Economic surplus	A+B+C+D+E+F+H	A+B+D+H+I – K	(C+E+F+K) – I (=deadweight loss)

In the absence of imperfect information the market would produce the efficient quantity (Q*) of quality widgets which is depicted directly below the intersection of D and S_{QUAL} in Figure 3. The equilibrium price would be P* and the level of consumer surplus would be the sum of areas **A + B + C**, and producer surplus would be areas **D + E + F + H**, with economic surplus being their combined amount (see Table 3).

The impact of imperfect information caused by the presence of credible counterfeit widgets can also be captured within Figure 3 by recognizing D′ as the relevant demand for widgets and S_{TOT} as the relevant supply, so that the equilibrium price of the good is $P_{w/CC}$ and the equilibrium quantity of widgets sold is Q′ (which happens to equal Q* in the figure, but it could be either larger or smaller). Consumer surplus would be **A + B + D** from the purchase of quality

widgets *minus* **J + K** which represents the money wasted by consumers on worthless sham widgets (Table 3 reports this level of consumer surplus). Producer surplus is equal to the area **H** which is earned by the producers of quality widgets *plus* **I + J** that is earned by the producers of the counterfeit widgets. Thus, economic surplus is **A + B + D + H + I** minus **K**.

The deadweight loss is the lost economic surplus caused by the imperfect information and is areas **C + E + F + K** minus **I** as shown at the bottom of the final column of Table 3. Once again the deadweight loss takes two forms. The first is due to the reduction in quality widgets being produced and sold which causes **C + E + F** to be lost (and is lightly shaded in Figure 3). This occurs because the price of widgets has fallen, which results from the demand for widgets falling (from concerns about possibly purchasing a worthless widget) as well as from the supply of widgets increasing due to the presence of the counterfeit widgets. The second form of deadweight loss is from the sale of counterfeit widgets where consumers' wasted spending (i.e., **J + K**) is unambiguously greater than the surplus gained by producers from the production and sale of the counterfeit widgets (i.e., **I + J**) which taken together net an additional deadweight loss of **K** minus **I**. If one assumes – as was done in the section above – that the producer surplus from the sham widgets equals half of the amount spent by consumers on those worthless widgets, then the deadweight loss is half of that amount spent (i.e., half of areas **J + K**, which is also shaded in Figure 3).

Equilibrium forces would promote consumers' expected (*ex ante*) consumer surplus (i.e., A+D+E+G) equaling the realized (*ex post*) consumer surplus (i.e., A+B+D – J – K), which would make B = E+G+J+K. If they were not equal then consumers would adjust their expected marginal valuations accordingly causing demand to shift to equate the two (e.g., if B < E+G+J+K then D′ would fall causing B to increase and E+G+J+K to unambiguously fall).

Although the above analysis directly shows how the existence of counterfeit widgets creates deadweight loss, it also provides clear insights to how an increase in the supply of credible counterfeit widgets (S_{CC}) causes greater deadweight loss. It does this by making clear how marginal increases in the supply of counterfeits will lower the price in two ways: By increasing S_{TOT} and by decreasing D′ due to the increased probability of a purchased widget being a counterfeit. The lower price would unambiguously add to the deadweight loss due to fewer quality widgets being produced, with each additional quality widget not produced increasing the deadweight loss more than the previous (given the slopes of the demand and supply curves). Meanwhile, the change in deadweight loss from more of the worthless counterfeits being sold can be positive or negative. Although the deadweight loss from introduction of counterfeits would initially get bigger, there would reach a point where additional increases in the supply of counterfeits would cause that component of the deadweight loss to fall, e.g., the sum of areas **J + K** would begin to get smaller, which would cause half of that area to fall. But by that point the additional deadweight losses from the reduced quantity of quality widgets sold would swamp any reductions in the deadweight losses from the greater sale of worthless widgets.

Correspondingly, any information that exposes the counterfeit widgets (and makes supplying them unprofitable) would increase social welfare by reducing the imperfect information that is causing the market to fail and bring about deadweight loss. Therefore, this model supports all the economic arguments for cultivating information that exposes existing low-quality counterfeit goods (despite it causing higher prices for the product). It captures the benefits of government policies that protect brand names of monopolistically competitive firms which allows those brand names to signal information about the quality of products to consumers

(since brand names provide incentives to produce quality goods). It does the same for government regulations which ensure that goods meet certain quality standards. It also encourages individual consumers to incur search costs in the form of screening and the producers of quality widgets to signal their products when the costs of doing so are sufficiently small. Of course, the costs of government support of monopolistic competition (e.g., increasing market power) and regulation (e.g., barriers to entry and regulatory capture) as well as the costs to market participants of screening and signaling efforts need to be recognized in any comprehensive welfare analysis.

The market specified by the above model differs from Akerlof's (1970) iconic used-car market in two ways. First, there is no production of low-quality used cars to sell. Instead, the supply of used-cars is taken from the existing stock of used cars. Second, the used car market presented by Akerlof collapses in a way that is not observed. The Appendix modifies the model to account for these two differences.

Conclusion

This paper has introduced a market model that exhibits the deadweight loss associated with imperfect information regarding the quality of each good that is supplied. The analysis supported by the diagram only requires that consumers are uncertain about each good's quality, which makes it hold for cases of asymmetric information in which producers are fully aware of the quality of the products they sell.

Illustrating deadweight loss within a market model is a fundamental feature of almost all principles of microeconomics courses and their textbooks where it is used to convey the social welfare costs of market failures and distortions: it is used to convey the detrimental effects of externalities, market power, taxes, tariffs, and quotas, and has even been used to show how markets for public goods fail. The only major market failure that has not had its harmful effects on social welfare depicted as deadweight loss is imperfect information. This paper offers a model that could be used to rectify that situation.

Figure 3 clearly depicts two different components of deadweight loss caused by imperfect information. The first is from the reduction in quality goods produced and sold due to the reduction in the goods' price, where that lower price is due to both the reduced demand by consumers who believe they might purchase a counterfeit good and the increased supply from the production of low-quality goods. The second component results from consumers spending money on low-quality goods and, therefore, experiencing less consumer surplus than expected if not negative consumer surplus that exceeds the increase in producer surplus associated with the production of those low-quality goods.

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Appendix: The Used Car Market as a Special Case

The model presented in this paper captures the effect of imperfect information (including asymmetric information) regarding the quality of a good or service that is for sale. It portrays the deadweight loss caused by the existence of poor-quality substitutes that cannot be distinguished from the genuine article at the time of purchase. But the most popular example of imperfect information in microeconomic textbooks is Akerlof's (1970) description of the asymmetric information that vexes the used car market, despite that market being very different than the typical market. This appendix modifies the model in two simple ways that tailors it to capture Akerlof's used car market. The modifications will highlight the differences between markets afflicted with the usual imperfect information that has motivated large numbers of government regulations and the used car market that is largely unregulated.

The first difference with the used car market is that no used cars are being produced, but rather, the supply of them is taken from the existing stock of used cars. Thus, the upward sloping supply only captures how higher prices persuade more people to sell their used cars. Given that there is no producer surplus from production, the producer surplus – from the sales of quality used cars as well as lemons – is simply the amount the sellers receive in excess of their reservation prices.

The portion of the deadweight loss due to the reduced sale of quality goods (represented by areas **C + E + F** in Figure 3) accurately captures a loss of economic surplus experienced by the used car market when low-quality used cars (i.e., lemons) are supplied along with quality used cars. But the remaining deadweight loss caused by consumer spending on lemons (represented by K **– I** in Figure 3) does not necessarily apply. It is accurate when the potential sellers of the lemons value them as indicated by the upward sloping S_{CC} curve (found as the horizontal distance between S_{QUAL} and S_{TOT}). But Figure 3 would misrepresent this second type of deadweight loss if the owners of the lemons regarded them as a liability and would gladly give them away (as would be the case in a world where the lemons' true values were transparent to all). This alternative case is captured by Figure A1 which shows that the stock of lemons would be sold at any price (causing S_{QUAL} and S_{TOT} to be parallel) so that the producer surplus from the sale of the worthless used cars (= **I + J**) would equal the amount the consumer pays for it (= **J + K**) since areas **I** and **K** are equal. Thus, everything spent by consumers on the worthless cars would represent negative consumer surplus and an equal amount of producer surplus to the sellers, so that there would be no net impact on economic surplus. Although the second type of deadweight loss discussed above is absent in this case, the unintended transfer could inflict psychological costs on the consumer and psychological benefits to the seller.

Figure A1. Deadweight Loss Due to Imperfect Information (Assuming Seller's Reservation Price for Lemons is Zero).

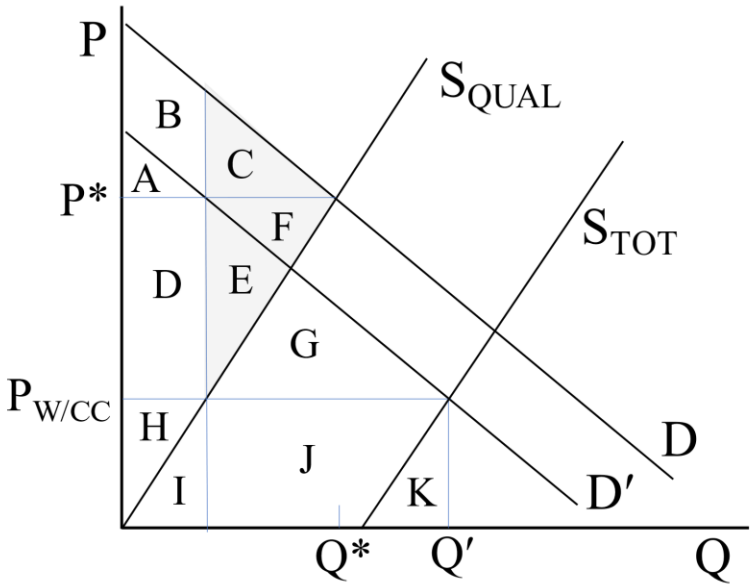

Table A1. Welfare Analysis Results from Figure A1.

	No Credible Counterfeits so that D = D & S = S_{QUAL}	w/ Credible Counterfeits so that D = D′ & S = S_{TOT}	Loss Due to Credible Counterfeits
Consumer Surplus	A+B+C	A+B+D – (J+K)	(C+J+K) – D
Producer Surplus	D+E+F+H	H+I+J	(D+E+F) – (I+J)
Economic surplus	A+B+C+D+E+F+H	A+B+D+H+I – K (= A+B+D+H since I=K)	(C+E+F) + (K – I) (=C+E+F since K=I) (=deadweight loss)

A second distinction of Akerlof's used-car market is that prospective sellers' valuation of their used cars is a simple linear function of their quality. Then having all of them only sell their used cars when they value them less than the market price effectively ensures that the average (or expected) sellers' valuation would be significantly less than that market price. This would require a buyer to value the good significantly more than the average seller's valuation for that buyer to undertake a purchase that might be a lemon. Akerlof's model required buyers to value a used car twice as much as sellers' average valuation for transactions to take place, which was a large enough difference to allow Akerlof to surmise that the used car market could collapse with no quality used cars being exchanged. The deadweight loss from a collapsed market would

include all consumer and producer surplus that would exist if only quality used cars were bought and sold (i.e., areas **A** through **F + H** in Figure 3 and Figure A1).

The impact of such asymmetric information within the model presented in this paper has it suffering deadweight loss without collapsing, and therefore, it does not capture Akerlof's market. But it is possible to modestly extend the new model to accommodate Akerlof's story. Note that Figure A1's specification of the whole stock of lemons being sold at any price causes the percentage share of used cars supplied that are quality used cars to fall as the price falls, which is precisely the critical feature of the used car market specified by Akerlof. This means that as the price falls, prospective consumers' odds of purchasing a lemon increases, which would dampen the increase in quantity demanded precipitated by the lower price. Therefore, a demand curve that factors in the greater likelihood of buying a lemon at lower prices would be steeper than if the share of used cars that are quality used cars did not fall with their price (as was specified in Figures 2 and 3).

Figure A2 shows the marginal social value curve (D) and the demand once the probability of purchasing a lemon is accounted for (i.e., D′), where the steepness of D′ reflects wary consumers' reaction to the increased likelihood of a used car being a lemon as the price falls. The figure reveals how a sufficiently steep demand curve combined with a sufficiently large number of worthless lemons being supplied can prevent quality used cars from being exchanged: the quantity demanded when the excess supply of used cars pushes the price to zero is less than the quantity supplied, and the only used cars exchanged (or, more correctly, given away) would be lemons. In this case no quality used cars would be sold. The corresponding deadweight loss from the collapsed market amounts to the economic surplus that would exist without the market failure and is lightly shaded in Figure A2. Note that an equilibrium market price would exist if the demand curve were to shift out and/or be less steep and/or the supply of lemons were to decrease sufficiently.

Figure A2. The Collapse of the Quality Used-Car Market Due to Imperfect Information.