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Computing welfare losses from data under imperfect competition with heterogeneous goods ☆

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ABSTRACT

We study the percentage of welfare losses (PWL) yielded by imperfect competition under product differentiation. When demand is linear, even if prices, outputs, costs and the number of firms can be observed, PWL is arbitrary in both Cournot and Bertrand equilibria. If in addition the elasticity of demand (resp. cross elasticity of demand) is known, we can calculate PWL in a Cournot (resp. Bertrand) equilibrium. When demand is isoelastic and there are many firms, PWL can be computed from prices, outputs, costs and the number of firms. We find that price–marginal cost margins and demand elasticities may influence PWL in a counterintuitive way. We also provide conditions under which PWL increases or decreases with concentration.

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1. Introduction

One of the most robust findings of Industrial Organization theory is that market equilibrium very often yields inefficient allocations. But how large are these inefficiencies? This topic has inspired a considerable amount of empirical research, from the paper by Harberger (1954) to the work of Cowling and Mueller (1978), among many others.

In contrast, the theoretical literature is sparse and focuses on the case of homogeneous products. In that case, when demand and costs are linear and firms are identical, it is well-known that the percentage of welfare losses (PWL) in a Cournot Equilibrium is $\frac{1}{(1+n)^2}$ where n is the number of firms. McHardy (2000) showed that when demand is quadratic, welfare losses can be 30% larger than in the linear model. Anderson and Renault (2003) calculated PWL for a more general class of demand functions. Johari and Tsitsiklis (2005) showed that if average costs are not increasing and the inverse demand function is concave, PWL is less than $\frac{1}{2n+1}$. Finally, Corchón (2008) offered formulae for PWL under free entry and heterogeneous firms. He showed that PWL can be very large under these conditions. The only paper dealing with heterogeneous products is by Cable et al. (1994), who studied a linear duopoly model.

In this paper we analyze PWL in two models of imperfect competition with heterogeneous products and a representative consumer with quasi-linear preferences: a model with linear demand functions, as per Dixit (1979) and Singh and Vives (1984), and a model with isoelastic demand functions, as per Spence (1976). In both models, firms produce under constant average costs.

Our first step is to find PWL as a function of the fundamentals, i.e., the parameters of the demand and cost functions. As these parameters cannot be observed, our second step is to obtain PWL as a function of observable variables: price, output, number of firms, etc. Where this is not possible, we introduce items that might be estimated such as elasticity of demand. The goal of our analysis is to study the impact of observable variables on PWL.[1] Even though PWL can be calculated

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[1] This paper does not focus on the maximal PWL. Since product differentiation reduces competition, PWL in our framework is at least as high as it would be under product homogeneity. See Footnote 7 for the case of identical firms and formulae (2.15), and (2.17) for the case of non-identical firms.

directly from the data on a case-by-case basis, our approach pinpoints the theoretical factors explaining PWL.

We first consider the model with linear demand. Assume that firms and demand functions are identical. We show that, given an observation of price, output, marginal cost and the number of firms, there exist parameters of the demand function that convert this observation into a Cournot or a Bertrand equilibrium such that PWL is arbitrary (Propositions 1 and 2). This result shows that PWL is unrelated to the differences among profit rates, contrary to Harberger's dictum: "The differences among these profit rates, as between industries, give a broad indication of the extent of resource malallocation" (op. cit. p. 79). In our model all firms have the same rate of return on capital but PWL can be high. It seems that Harberger's procedure picks up welfare losses stemming from the failure of markets to equalize profit rates, and not welfare losses from oligopolistic misallocation. The issues are related, but distinct.

Next we show that if the elasticity of demand can be estimated, PWL in a Cournot equilibrium can be computed from observables (Proposition 3). The elasticity of demand does not add any new information in the case of a Bertrand equilibrium because it can be obtained from the markup and the first-order condition of profit maximization. We show that if the cross elasticity of demand can be estimated, PWL can be computed from observations (Proposition 5). Finally, we study how PWL depends on these variables (Propositions 4 and 6). Some results are as expected, but others are not: PWL is decreasing on the price–marginal cost margins (often referred to as the "monopoly index", Lerner, 1934), for example, in both Cournot and Bertrand equilibria.[2] Another surprising result is that PWL increases with the elasticity of demand in a Bertrand equilibrium. Why is this so? Consider two markets, A and B, and let the price–marginal cost margin be larger in A than in B. This means that the triangle that represents welfare losses is larger in A than in B. However, the realized welfare is also larger in A than in B because the demand function in A is above the demand function in B. *A priori*, there is no good reason to expect that one effect is larger than the other. In fact, as we noted before, when costs and demand are linear and firms are identical, these two effects cancel each other out and PWL only depends on the number of firms.[3] The same argument goes for demand elasticity: a larger demand elasticity means less welfare losses and less realized welfare, so the total effect is ambiguous.

Next we introduce heterogeneity in demand and costs. We focus on the relationship between concentration and welfare losses. Some papers have found that the Hirschman–Herfindahl (H) index of concentration is not a good measure of welfare losses. Daughety (1990) came to this conclusion because more concentration may be associated with a larger output in a leader–follower equilibrium. In papers by Farrell and Shapiro (1990), Cable et al. (1994) and Corchón (2008), the same result was related to the fact that the firms could be of different sizes.[4] This finding contrasts with the 1992 Merger Guidelines issued by the Federal Trade Commission (FTC), where H is considered a reasonable measure of welfare losses (Coate, 2005). We show that when it is optimal to allow all firms to produce, PWL increases with H in both Cournot and Bertrand equilibria (Proposition 7). This case arises when goods are poor substitutes. We also show that when it is optimal to allow only one firm to produce, PWL decreases with H. This is what happened in the papers cited above where products are perfect substitutes.

Thus, we find that concentration is bad (good) for welfare when goods are poor (good) substitutes. The reason is that efficient production must balance cost savings against consumer satisfaction. The former favors concentrating production in the most efficient firms, while the latter may require considerable diversification of production. If the last effect is not very large (i.e., when the products are close substitutes), cost savings drive efficiency and thus concentration does not harm efficiency. If the products are poor substitutes, however, efficient production requires output dispersion so concentration is harmful. We also show that at the value of H proposed by the FTC as a threshold for a concentrated industry, PWL is large in a Cournot equilibrium but may be small in a Bertrand equilibrium.[5]

In Section 3 we assume that the representative consumer has preferences representable by a CES utility function. We also assume a large number of identical firms. This model (Spence, 1976) and its variants (e.g. Dixit and Stiglitz, 1977) are popular in the fields of monopolistic competition, international trade, geography and economics. We depart from these models, however, by assuming that the number of firms is exogenous. The reason for this difference is that to endogenize the number of firms we need fixed costs, which may produce large PWL (Corchón, 2008). Since in this paper we want to focus on the PWL produced by product heterogeneity, we must assume that the number of firms is given. We show that PWL tends to zero as demand elasticity tends to infinity, and that PWL tends to one as the degree of homogeneity of the CES function tends to one (Proposition 8). This result qualifies a conjecture of Stigler (1949): "... the predictions of this standard model of imperfect competition differ only in unimportant respects from those of the theory of competition because the underlying conditions will usually be accompanied by very high demand elasticities for the individual firms". Although a high elasticity of demand makes PWL small in this model, given any elasticity of demand we can obtain a PWL as close to one as we wish.

Next, we show that PWL can be recovered from an observation of the price, output, marginal cost and number of firms (Proposition 9). However, a low price–marginal cost margin does not guarantee that PWL is small; even if the price tends to the marginal cost, when the number of firms is sufficiently large, PWL may exceed that obtained in a linear model under monopoly. Moreover, when the number of firms tends to infinity, PWL is decreasing in the price–marginal cost margin (Proposition 10). This is another case where price–marginal cost margins and welfare losses are not related in the way we had previously thought.

Summing up, we have three main conclusions. First, our main message is positive: obtaining PWL from data is possible in two well-known models of imperfect competition. Second, the roles of rates of returns, markups and the elasticity of demand on PWL are not always what they have been thought to be. Finally, we explain the role of the H index. Our formulae unify previous views on the role of elasticities, markups and concentration in a precise way, with results that may be useful for policy making.

2. The linear model

In this section we assume that inverse demand is linear and that goods are substitutes.[6] In the first subsection we assume that all firms are identical, which allows for clean formulae of welfare losses. In the second subsection we study the case where costs and the intercepts of inverse demands vary among firms. The resulting formulae for PWL will then be used to discuss the role of concentration in oligopolistic markets.

[2] This was noted by Formby and Layson (1982) in the case of monopoly.

[3] In other words, price–marginal cost margins do not control for the size of demand. Thus, a high margin might indicate either that demand is very large and firms are having good times–even if they are very competitive–or that firms are "exploiting" consumers and destroying a large part of the surplus. This is true even if actual production is known, because the price-marginal cost margin is a poor indicator of efficient production.

[4] The point that minor firms may be harmful for welfare was first made by Lahiri and Ono (1988).

[5] Despite the fact that, as shown by Amir and Jin (2001), H is always higher in a Bertrand equilibrium than in a Cournot equilibrium.

[6] We study the case of complements in a companion working paper (Corchón and Zudenkova, 2008).

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