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Interpreting economic data: estimating the elasticity of demand

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Interpreting Economic Data

Estimating the elasticity of demand

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Introduction

The concept of elasticity of demand is one of the most important in economics. At its most general level the elasticity of demand measures the percentage response in demand to a given percentage change in some other variable of interest. For example, we are often interested in the response of demand to changes in the price of the good concerned – the *own price elasticity of demand* – but we may also be interested in the response to changes in income – the *income elasticity of demand* – or changes in the prices of other goods – the *cross price elasticity of demand*. In a recent article for the *Economic Review*, Mark Russell shows how useful the concept of elasticity of demand can be for both economists and the business community. He also shows how demand elasticities can be calculated and gives examples of how they might be used in practice.

In this article we will use data taken from the UK *Family Expenditure Survey* (FES) to estimate elasticities of demand for various groups of commodities. The aim is to determine how the demand for different types of goods is likely to change as the economy grows. We will see that for some products, such as motoring and leisure services, demand is likely to grow at a faster rate than the economy as a whole. However, there are other products, such as tobacco and household fuels, for which growth in demand is largely unrelated to the general growth of the economy.

The plan of the article is as follows. In the next section we will define the concept of the elasticity of demand more precisely and discuss how it will be applied in this article. This is followed by a description of the data set we will be using. We then present estimates of the elasticity of demand for a number of groups of products based on the FES data for 1999-2000. Finally, we present some general conclusions and some suggested questions and exercises based on this article.

The elasticity of demand

Suppose q is the quantity demanded and p the price of a good. We can define the price elasticity of demand for the good as the proportionate (or percentage) change in quantity demanded divided by the proportionate (or percentage) change in price. Writing this in the form of an equation gives $e_p = \frac{\Delta q/q}{\Delta p/p}$ where e_p is the price elasticity of demand and the symbol Δ indicates a change in the variable. This definition is easily generalised to other types of elasticity such as the income or cross-price elasticities of demand. Note that since demand normally falls as price increases the own price elasticity of demand will normally take on a negative value. In many applications therefore the own price elasticity is *normalised* by multiplying by -1 in order to report it as a positive number.

In this article we will be particularly concerned with the estimation of the *total expenditure elasticity of demand* for a good. This measures the proportionate response of demand to a given proportionate increase in aggregate expenditure. In equation form we could write this elasticity as $e_x = \frac{\Delta q/q}{\Delta x/x}$ where x is total expenditure. We can think of this elasticity as giving us a measure of how expenditure levels on different goods are likely to change as the total level of expenditure increases. It can therefore give us a guide as to the likely changes in expenditure patterns which will occur as the economy grows. In practice the decision to focus on this particular elasticity is pragmatic – it is relatively easy to get the necessary data to generate estimates for this measure. Other related definitions of the elasticity of demand (for example the income elasticity) are considerably harder to estimate using the particular data set with which we will be working.

The Data

The *Family Expenditure Survey* (FES) data set is based on interviews with over 7,000 households who keep a detailed diary of their expenditure patterns over a period of time. Summary tables of the data collected are then published by the *Office for National Statistics* (ONS) both in print form and via the world wide web <http://www.statistics.gov.uk/>. The resulting data set enables researchers to analyse the structure of demand for goods and services within the UK to a very high degree of detail. For example, Table 1 gives data which can be used to analyse the demand for housing:

Table 1: Expenditure Data by Household

| Income Decile | Expenditure on Housing by Household £ per week | Total Expenditure by Household £ per week | Average Number of Household Members |
|---------------|--|---|-------------------------------------|
| 1 | 19.8 | 119.7 | 1.3 |
| 2 | 23.8 | 146.8 | 1.7 |
| 3 | 29.6 | 178.1 | 1.9 |
| 4 | 42.1 | 244.8 | 2.0 |
| 5 | 50.9 | 300.0 | 2.2 |
| 6 | 57.9 | 361.8 | 2.5 |
| 7 | 66.0 | 412.9 | 2.6 |
| 8 | 72.5 | 481.8 | 2.9 |
| 9 | 86.7 | 565.2 | 3.0 |
| 10 | 120.8 | 782.5 | 3.1 |

Source: Family Expenditure Survey 1999-2000

The presentation of the data in Table 1 is by income decile. For example, the first income decile consists of those households with incomes corresponding to the lowest 10% of the sample. The second income decile consists of those households whose incomes lie between the lowest 10% and the top 80% and so on. The figures given in the Table

consist of housing expenditure and total expenditure by household as well as the average number of persons per household within each income decile.

It is obvious from Table 1 that there is a positive relationship between income and the number of people making up the household. This is not surprising as larger households are likely to contain more wage earners than smaller households. Given this relationship, it makes sense to scale the data by the average number of persons per household in order to focus on the underlying relationship between income and expenditure. Table 2 gives figures for the two types of expenditure scaled by the average number of persons per household. Even after scaling the data in this way there is still a clear, positive relationship between income and both housing and total expenditure.

Table 2: Housing and Total Expenditure by Income Decile

| Income Decile | Expenditure on Housing by person £ per week | Total Expenditure by person £ per week |
|---------------|--|---|
| 1 | 15.2 | 92.1 |
| 2 | 14.0 | 86.4 |
| 3 | 15.6 | 93.7 |
| 4 | 21.1 | 122.4 |
| 5 | 23.1 | 136.4 |
| 6 | 23.2 | 144.7 |
| 7 | 25.4 | 158.8 |
| 8 | 25.0 | 166.1 |
| 9 | 28.9 | 188.4 |
| 10 | 39.0 | 252.4 |
| Average | 23.0 | 144.1 |

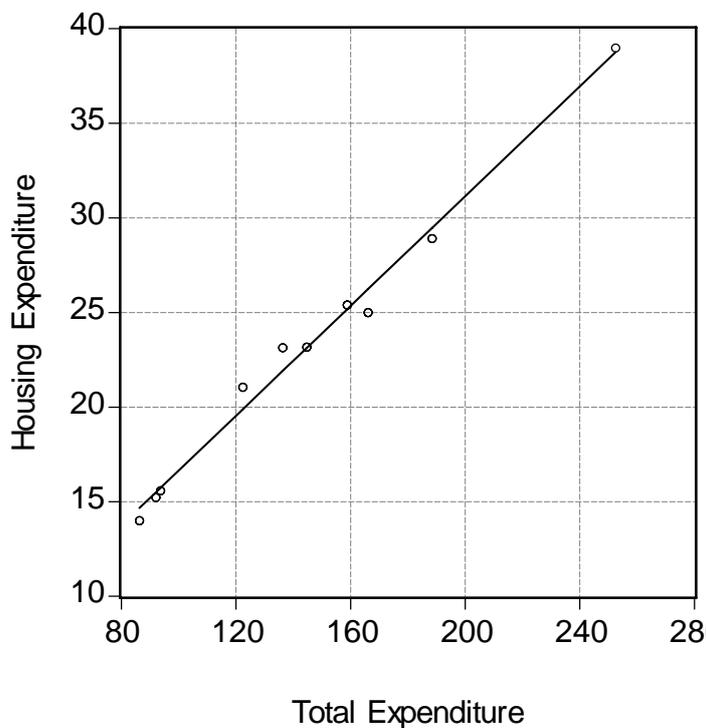
Source: Family Expenditure Survey 1999-2000

Having scaled the data we now proceed to estimate the expenditure elasticity of demand for housing. This requires two stages. The first involves the estimation of the ratio $\Delta q_h / \Delta x$ where q_h is housing expenditure and x is total expenditure. The second involves

the use of this estimate to calculate a value for the elasticity using the average values of housing and total expenditure to calculate the ratio $\frac{x}{q_h}$.

To estimate the relationship between the change in housing expenditure and that in total expenditure we first plot the scatter diagram of housing expenditure against total expenditure and calculate the best fit line. The results obtained are shown in Figure 1. The equation of the best fit line can be shown to be $q_h = 2.14 + 0.145x$. A common mistake is to believe that the slope coefficient from this line is the same as the expenditure elasticity of demand. In fact the slope of the line in Figure 1 measures the marginal propensity to spend on housing with respect to total expenditure. Therefore in this case it is showing us that on average out of every £1 increase in total expenditure just less than 15p will be on housing.

Figure 1: Housing Expenditure against Total Expenditure



The expenditure function shown in Figure 1 is related to the *Engel Curve* which is discussed in many microeconomics textbooks. An Engel Curve gives the relationship between the demand for a product and income. This is not exactly the relationship given in the diagram since this relates expenditure on housing to total expenditure on all goods and services. However, since there is a very close relationship between income and total expenditure (see Table 1) it follows that the curve shown above is a reasonable approximation to the Engel Curve. Since the slope is positive it follows that housing is a *normal good* i.e. an increase in income leads to an increase in the demand for housing.

To estimate the elasticity of demand for housing we must adjust the slope coefficient by multiplying by the average total expenditure and dividing by average housing expenditure to obtain a measure of the elasticity. In this case we have average total expenditure equal to £144 per week and average housing expenditure equal to £23 per week. It follows that the expenditure elasticity of demand can be calculated as $0.145 \times 144 \div 23 = 0.91$. This is actually something of a simplification since the elasticity of demand will vary as we move along the curve shown and the estimate derived here is for the midpoint only. However, the range within which the elasticity varies is relatively small and the midpoint provides a good estimate.

Comparing elasticities of demand for different goods

In the previous section we used data from the FES to estimate the expenditure elasticity of demand for housing. Now we apply the same methods to a variety of other types of good in order to compare the values of the elasticity which we obtain. Table 2 below gives the information we need to make the calculations. In each the elasticity is obtained by dividing the value given in the first column by that given in the third column.

Table 2: Expenditure Elasticity Calculations

| Commodity or Service | Slope of Expenditure Function | Average Weekly Expenditure on Commodity or Service (£) | Ratio of Expenditure on Commodity to Total Expenditure | Estimated Elasticity |
|------------------------------|-------------------------------|--|--|----------------------|
| Housing | 0.145 | 23.04 | 0.160 | 0.91 |
| Fuel and Power | -0.006 | 5.00 | 0.035 | -0.17 |
| Food and non-alcoholic drink | 0.093 | 24.67 | 0.171 | 0.54 |
| Alcoholic Drink | 0.044 | 6.08 | 0.042 | 1.04 |
| Tobacco | -0.007 | 2.66 | 0.018 | -0.38 |
| Clothing and Footwear | 0.068 | 8.26 | 0.057 | 1.19 |
| Household Goods | 0.078 | 12.44 | 0.086 | 0.90 |
| Household Services | 0.051 | 7.67 | 0.053 | 0.96 |
| Personal Goods and Services | 0.037 | 5.60 | 0.039 | 0.95 |
| Motoring | 0.215 | 20.18 | 0.140 | 1.54 |
| Fares and Other Travel Costs | 0.035 | 3.58 | 0.025 | 1.41 |
| Leisure Goods | 0.055 | 7.33 | 0.051 | 1.08 |
| Leisure Services | 0.186 | 17.07 | 0.118 | 1.57 |
| Miscellaneous | 0.005 | 0.55 | 0.004 | 1.31 |
| Total | 0.999 | 144.14 | 1.000 | |

Let us first consider the estimates of the slopes of the expenditure functions given in the first column of Table 2. From the table we see that all but two of these slope estimates are positive. The two exceptions are the demand for Fuel and Power and the demand for Tobacco. If we again interpret these slope coefficients as estimates of the slope of the Engel curves then we would interpret this result as saying that the Fuel and Power and Tobacco are inferior goods. An inferior good is one for which demand falls as income rises. It can be argued that this makes economic sense. As incomes rise households may be able to afford to invest in energy saving appliances and energy savings measures which reduce their demand for fuel. Similarly, if there is a correlation between education and income, it may be that on average higher income households are more aware of the

health risks of tobacco consumption leading to a reduction in demand. Of course these arguments are speculative but they do seem to be intuitively plausible.

Next consider the interpretation of the slope coefficients of the expenditure functions. We have already stated that these can be regarded as the marginal spending propensities as aggregate expenditure rises. It follows that if we add the individual coefficients then this sum should be one. However, we have estimated each coefficient individually so there is no statistical reason why this should be the case. It follows that a check on the overall consistency of our estimates is to check if the slope coefficients do indeed sum to one. In fact the sum is very closely consistent with this hypothesis with the coefficients adding to 0.999. This increases our confidence that our expenditure model is a reasonable one.

Finally, we turn to the expenditure elasticity estimates given in column four. These estimates allow us to assess the effects of a general increase in expenditure on the demand for particular commodity groups. Inferior goods can be defined as those goods for which the income elasticity of demand is negative and in this case only fuel and power and tobacco would fall into this category. However, there is now another important division evident in the Table between those commodities for which the elasticity is less than one and those for which it is greater than one. For example, our estimates would indicate that motoring and leisure services fall into the category of luxury goods since their elasticities are considerably larger than one. In other cases it is harder to make a definitive judgment since the elasticities are often very close to one in value.

Conclusions

In this article we have used data from the Family Expenditure Survey (*FES*) to estimate the elasticity of demand for various commodity groups with respect to total expenditure. These elasticities are important because they help us to understand how the structure of demand is likely to change as the economy grows. For example, our estimates indicate that the demand for fuel and power is unlikely to grow by much as the economy expands while the demand for motoring and leisure services is likely to be buoyant.

Questions for further thought and discussion

1. Consider the introduction of a new product into the market e.g. DVD players. How might you expect its expenditure elasticity of demand to change over time?
2. Suppose the demand curve for a good is given by the following expression $q = 20 - 0.2p + 0.02x$ where q is quantity demanded, x is total expenditure and p is price. Use this information to calculate the price and income elasticities of demand when $p = 10$ and $x = 100$.
3. From the estimates in Table 2 we find that the expenditure elasticities of demand for food and fuel are relatively low. Empirical studies have found that the price elasticities of demand are also relatively low. Explain why you might expect this to be the case.