

Alternative Techniques of Estimating Import Demand Elasticities

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THE desirability as well as the difficulty of obtaining reliable estimates of import demand elasticities is clearly demonstrated by the extensive literature on the subject during the last few decades. Interest in price elasticities of import demand originated in Marshall's [14] discussion of the possibility of a devaluation causing a deterioration rather than an improvement in the balance of payments. Since then, the use of price elasticities in theoretical and empirical work has become widespread. Price elasticities have, for example, been employed extensively in analysing the effects of tariff elimination within the EEC and the effect of the "Kennedy round" tariff reductions on world trade patterns. Income/output elasticities of import demand are also exceedingly useful tools. For example, they enable us to assess the implications for total import demand of different projected growth rates of gross national product (GNP). The estimation of import demand elasticities is thus a matter of considerable importance for economic policy.

To obtain useful elasticity estimates still remains a difficult task. Data limitations such as the absence of quarterly GNP, inventory level and capacity utilisation series bedevil much empirical work on demand functions. The simultaneous-equation bias, to which Orcutt [16] referred in his classic 1950 article, continues to cause concern, even though the direction of and reasons for the bias are now better understood than ever before. There is also the question of what we mean by a "price" elasticity. Import prices may change for a number of reasons—the foreign *c.i.f.* price may change, tariffs may be imposed or reduced, or a temporary levy may be placed on imports for balance of payments purposes. Kreinin [10] and Krause [9] have argued that the reaction of import demand varies according to the type of price change involved. Thus there exists not one but two or maybe three types of price elasticity for imports.

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These issues have already been widely discussed in the literature and are not further pursued in this article. Instead, we confine our attention to three distinct problems of import demand estimation on which, it is hoped, the empirical results of the present author's study of Irish import demand [12] will cast some light. The three problems are as follows:

- (a) the value of aggregate as opposed to disaggregate elasticity estimates,
- (b) the sensitivity of elasticity estimates to differences in the specification of the import demand equation, and
- (c) the compatibility between "direct" and "indirect" estimates of import demand.

We shall discuss each issue in turn.

Aggregate and Disaggregate Estimates

The problem of aggregation is one of the most familiar in economics and requires no elaborate explanation here. The "aggregation bias" to which trade theorists refer attaches to the price coefficient of an aggregate import equation. They argue that price changes are largest for goods with inelastic demand and that consequently the aggregate price coefficient is biased downwards. Needless to say, the output/income coefficient is also distorted by aggregation in so far as the marginal propensity to import different categories of goods vary and the composition of total imports changes—but the direction of the bias in this case cannot be predicted. Disaggregation, therefore, appears desirable on a number of counts.

On the other hand, despite its theoretical advantages, the fact that the correct specification of the disaggregate functions is typically unknown means that the results of disaggregation may often prove disappointing in practice. Grunfeld and Griliches [4] for instance, have discovered cases where an aggregate equation explains the data more satisfactorily than a set of disaggregated equations. Ball and Marwah [3] in their study of US import demand also found that, as far as explaining past data is concerned, their aggregate equation registers as much success as the disaggregate equations combined. Clearly there is no easy way of disposing of the aggregation bias, while at the same time avoiding new sources of error.

That the aggregation bias cannot automatically be corrected by disaggregation is clearly illustrated by reference to Irish data. Imports were divided into three groups: consumer goods (CG), materials for further production (MFP) and producers' capital goods (PCG). Demand functions for each group were estimated separately. A combined disaggregate (or, in Ball and Marwah's terminology, a "composite") elasticity was then formed as the weighted average of the three individual price or income/output elasticities, the weights being determined by the share of each import group in total imports. These combined disaggregate price and income/output elasticities are thus directly comparable with the price and income/output elasticities obtained from the aggregate import demand equation. The two sets of elasticities are presented in Table 1.

TABLE I: *Aggregate and Combined Disaggregate ("Composite") Elasticities and Projections of Irish Import Demand 1966-76*

1. Elasticities	Price		Income/Output	
	lower est.	upper est.	lower est.	upper est.
Aggregate	-0.92	-1.53	1.87	2.15
Combined disaggregate	-0.54	-0.96	1.83	2.23
2. Projections (£m. 1966 prices)		Lower est.		Upper est.
Total Disaggregate:				
increase due to price	58.3		113.2	
increase due to output/ income	<u>386.1</u>	384.4	<u>399.4</u>	512.6
Aggregate				
increase due to price*	65.0		104.7	
increase due to output/ income	<u>325.1</u>	390.1	<u>386.4</u>	491.1

*The average price change is defined as the weighted average of the price change of each import component, the weights being proportional to that component's share in total imports in 1966.

Aggregate price elasticities lie within the range -0.92 to -1.53 , significantly below the corresponding range -0.54 to -0.96 for the combined disaggregate price elasticity. It is thus immediately apparent that disaggregation fails, in this instance, to correct the downward aggregation bias which on theoretical grounds we might expect to find in the aggregate price elasticity.¹ Perhaps this merely means that the aggregation bias does not in practice result in any serious distortion. Alternatively, the bias may indeed be important, but the imperfect specification of the disaggregate equations prevents it from being detected. Clearly, there is no way of knowing which explanation carries most weight without further investigation.

It is possible that the important distinction between aggregate and disaggregate estimates hinges on the different projections of imports they provide, rather than the discrepancy between aggregate and combined disaggregate elasticities *per se*. To test this hypothesis, two sets of projections for Irish import demand were prepared. One projection was obtained from the aggregate equation, the other being derived as the sum of the three disaggregate projections.

¹The bias refers only to the price elasticity, not to the income/output elasticity. It is interesting to note the close correspondence between the aggregate and combined disaggregate income/output elasticities.

Assuming a GNP growth rate of 4 per cent per annum, the income/output effects for aggregate and for total disaggregate imports are calculated over a ten-year period. Upper and lower bound projections are obtained on the basis of corresponding upper and lower bound elasticity estimates.

To compute aggregate price effects, we define the average price change (to which the aggregate price elasticity was applied) as the weighted average price change of each import component, weights being proportional to 1966 import shares. The total disaggregate price effect is simply the sum of each component's price effect. We assume a fall in relative import price of 40 per cent, 15 per cent and 5 per cent for CG, MFP and PCG imports respectively over the ten years.²

Table 1 contains a summary of the two sets of projections. In general, the differences between them appear slight. A remarkable feature of the projections, however, is the similarity between the aggregate and total disaggregate price effects. A price effect of £65 to £105 m. emerges from the aggregate elasticities compared to a corresponding effect of £58 m. to £113 m. on the basis of the individual disaggregate equations. The two projections differ only in that the range specified by the disaggregate projection is wider than that of the aggregate. In view of the lower combined disaggregate price elasticity, one might have expected the disaggregate projections to lie below the aggregate projections.

This paradox may be explained as follows. The average price change applied to the aggregate import elasticities is obtained by weighting the price change for each individual import group by its share in total imports. No account is taken of the magnitude of each group's price elasticity. Hence if the price of the highly elastic goods (CG imports in our example) falls by more than the price of the less elastic goods, the use of aggregate elasticities will after a point lead to an underestimation of the true expected rise in total imports.

We have thus shown that discrepancies between aggregate and combined disaggregate elasticities need not necessarily be reflected in import demand projections. It follows equally that equivalence between the two sets of elasticities need not imply that projections on the basis of aggregate elasticities will be the same as those based on the combined disaggregate elasticities. Bearing in mind the fact that disaggregation involves additional sources of error due to both data and specification problems, it is advisable to estimate both an aggregate and a set of disaggregate import demand equations.

Specification Problems

A wide variety of functional forms exists with which to express the relationship between imports and the explanatory variables. Although others are available, the customary choice is between linear and log linear versions. The latter implies a declining elasticity with respect to price and approximately a unit elasticity with respect to output, as output and income grow overtime. It is

²For further details, see McAleese [12].

difficult to know, on *a priori* grounds, which version one would prefer. Usually, the choice is made on the basis of a comparison between the coefficient of determination and standard error of the two versions. The empirical results often suggest no strong case for one over the other, so a range of elasticity values is quoted which includes the log-linear and the linear estimates.

Static import demand models, in which imports are expressed as a function of current values of the exogenous variables, have frequently been criticised on the grounds that one cannot expect adjustments to changes in income and price to be instantaneous. It is necessary, therefore, to introduce a time dimension into the analysis. Three ways of doing this are now examined.

In their recent study of U.S. import demand, Houthakker and Magee [8] employ a stock-adjustment model. A distinction is made between desired imports m^* and actual imports m . With y and p referring to real income and price respectively, a simplified version of the stock-adjustment model is as follows (u is a disturbance term):

$$(1.1) \quad m^*_t = a_0 + a_1 y_t + a_2 p_t + u_t$$

$$(1.2) \quad m_t - m_{t-1} = \theta(m^*_t - m_{t-1})$$

the reduced form equation derived from (i) and (ii) is:

$$(1.3) \quad m_t = a_0 \theta + a_1 \theta y_t + a_2 \theta p_t + (1 - \theta)m_{t-1} + \theta u_t$$

Houthakker and Magee express their model in continuous terms and hence derive a somewhat different reduced form estimating equation, but the same underlying structure is assumed.

Distributed lag models are a commonplace in econometric work and are extensively used in import demand studies. Models of this sort draw no distinction between desired and actual imports. Imports, however, are expressed as a function of expected or "permanent" rather than current values of the independent variables. The model thereby enables us to separate long-run, and short-run or "impact" demand elasticities. As in the stock-adjustment model, unobservable variables are converted into observable series by a process of judicious substitution. A typical distributed lag reduced form equation is as follows:

$$(1.4) \quad m_t = a_0 + a_1 y_t + a_2 p_t + a_3 m_{t-1} + u_t$$

Impact demand elasticities are obtained from the coefficients a_1 and a_2 . To derive long-run elasticities, these coefficients must be divided by $(1 - a_3)$. Provided $0 < a_3 < 1$, it is evident that long-run elasticities are larger than impact elasticities.

One deficiency of the simpler (Koyck) distributed lag analysis should be noted: the same exponentially declining reaction pattern is imposed on all the independent variables. Alternative lag structures could be assumed, but none that at once so

efficiently minimise the multicollinearity problem and at the same time are easy to compute. Almon lag structures permit a more sophisticated weighting of lagged values of the independent variables but appropriate computer programmes are not readily accessible.³ Rectangular and inverted V lag structures have been applied in investment analysis with some success, but their use has not yet been extended to import demand estimation.

A model used by Houthakker-Taylor [6] differs from the two preceding models in that a stock variable is explicitly introduced into the equation. The basic structural equation expresses imports as a function of income (y), prices (p) and lagged stock (s):

$$(1.5) \quad m_t = a_0 + a_1 y_t + a_2 p_t + a_3 s_{t-1}$$

By manipulation and making certain assumptions about depreciation and desired capital stock, the unobservable stock term can be eliminated and we derive the estimating equation:

$$(1.6) \quad m_t = b_0 + b_1 m_{t-1} + b_2 \Delta y_t + b_4 y_{t-1} + b_3 \Delta p_t + b p_{t-1} + u_t$$

Δ = first difference

u = disturbance term.

Structural parameters can be easily derived from the reduced form equation, using least squares.

Although the introduction of a surrogate stock term is a desirable step forward, since import demand does indeed fluctuate with the levels of stock, the Houthakker-Taylor model has not yielded satisfactory results when applied to import data. Its explanatory power has been found to be significantly less than that of the distributed lag model. Furthermore, on a number of occasions, the value of the stock coefficient a_3 has been positive. Houthakker and Taylor justify this result by reference to habit-formation. Drawing a distinction between "physical" and "psychological" stocks (the latter representing total past consumption of a commodity) they argue that for durable capital goods the stock coefficient should be negative, whereas for non-durable consumer goods it should be positive, since the more of a commodity one has consumed in the past the more one will desire in the present. This rationalisation of a positive stock coefficient and the asserted equivalence of physical and psychological stocks lacks conviction. At best it sounds like an awkward evocation of a consumer "ratchet" effect which can just as easily be expressed in terms of a distributed lag model. Not

³Officer and Hurtubise [15] are the first, to our knowledge, to apply Almon lags in international trade. We may expect them to be used more commonly in future.

surprisingly the authors themselves have recently described it as *une idée peu évocatrice* [7, 219]⁴.

It frequently happens that more than one structural system is consistent with a single reduced form equation. Thus the reduced form equations of stock-adjustment (1.3) and the distributed lag (1.4) models contain exactly the same variables. Equally the distinction between the Houthakker-Taylor equation (1.6) and the stock-adjustment and distributed lag equations is slight. At the same time the interpretation and economic significance of the parameters differs considerably. Unfortunately, it is by no means unusual to find highly sophisticated models being tested by reduced form equations which are consistent with much simpler and more homely hypotheses. This often makes it difficult to evaluate adequately the usefulness of the model.

The foregoing arguments would suggest that a strong *a priori* case could be made for using a distributed-lag equation in preference to a static equation. The Houthakker-Taylor model, on the other hand, appears to have less to recommend it than the distributed lag equation, but by taking explicit account of dynamic factors it may also be expected to prove superior to the static equation.

In our import demand study, all three versions were tested. The salient features of each equation, both aggregate and disaggregate, are recorded in Table 2. From the information provided in this table, three conclusions may be drawn.

First, the magnitude of the income/output elasticities remain relatively invariant with respect to changes in specification. To judge from the results of the aggregate equation, a similar conclusion may well apply to the price elasticities. Unfortunately, the range of comparison has been limited by the low significance level of the disaggregate equations' price variable.

Secondly, the fit of the distributed lag equation is noticeably superior to that of the other two equations. In all cases, the correlation is higher and the standard error lower. The Durbin-Watson statistic is more favourable, but this tends to follow automatically from the presence of a lagged endogenous variable in the equation.

Thirdly, the Houthakker-Taylor equation occupies an intermediate position, in terms of closeness of fit, between the distributed lag and the static. The advantages which might have been expected to accrue as a result of the greater sophistication of the Houthakker-Taylor model, failed in this instance to materialise.

Despite its favourable showing in this and other studies of import demand,

4. An ambitious but in our view unsuccessful effort has been made by Turnovsky [17] to combine the stock-adjustment and the Houthakker-Taylor models in his study of New Zealand's imports. Turnovsky justifies his use of a Houthakker-Taylor approach by the high proportion of durable goods in total New Zealand imports. Despite this the coefficient of stock has a positive sign, an inconvenient result to have to explain away. There are a number of points on which one could take issue with Turnovsky's specification of the estimating equation, however, which might account for his rather strange results. To test the validity of this specification, Turnovsky-type equations were run on Irish data. Unfortunately, the fit was very poor, the coefficients were insignificant and the results generally not worth reporting.

TABLE 2: *Static, Distributed-lag and Houthakker-Taylor Equations for Irish Imports*

Equations	Coefficients and <i>t</i> ratios							R ²	DW	SE	Elasticities	
	<i>y</i>	<i>p</i>	Δy	Δp	y_{-1}	p_{-1}	m_{-1}				Income, output	Price
1. Aggregate Imports												
Static	0.2496 (16.87)	-0.5154 (3.34)						0.96	1.16	3.07	2.09	-0.89
DL	0.1378 (3.04)	-0.3582 (2.31)					0.4248 (2.59)	0.97	2.00	2.84	2.00	-1.08
HT			0.2094 (1.69)	-0.2129 (0.65)	0.1341 (2.83)	-0.3523 (2.02)	0.4331 (2.34)	0.97	1.93	2.89	1.91	-1.07
2. Producers' Capital Goods												
Static	0.0894 (10.52)							0.82	1.50	1.31	1.64	*
DL	0.0741 (4.23)						0.2250 (1.36)	0.84	1.97	1.22	1.75	*
HT			0.0749 (1.14)		0.0740 (3.45)		0.2255 (1.30)	0.84	1.97	1.23	1.75	*
3. Materials for Further Production												
Static	0.2683 (15.33)	-0.0250 (1.95)						0.86	1.77	2.80	1.02	-0.08
DL	0.1204 (2.47)	-0.0302 (2.58)					0.5747 (3.91)	0.92	2.03	2.46	1.09	-0.21
HT			0.1241 (2.25)		0.1895 (3.13)		0.3744 (2.05)	0.91	1.80	2.63	0.96	*
4. Consumption Goods												
Static	0.0521 (7.78)							0.82	1.90	1.27	2.03	*
DL	0.0273 (3.13)						0.4814 (3.31)	0.95	2.22	0.72	2.04	*
HT			0.0705 (3.29)		0.0117 (1.08)		0.7760 (4.32)	0.91	2.33	0.93	2.03	*

Note: DL = distributed lag. HT = Houthakker-Taylor. *y* = the "activity" variable, income or output. *p* = the relative price variable. Elasticities for DL and HT equations are long run elasticities. *Price variables not significant at the 5 per cent confidence level.

the Koyck distributed lag equation is not, for reasons already mentioned, completely satisfactory. In time, more probing and complex lag structures will doubtless be employed. Also, wherever data on capital stock and inventory series becomes available, we may look forward to seeing more rigorous empirical tests applied to models of the Houthakker-Taylor type.

Indirect versus Direct Elasticities

Import demand elasticities may be estimated indirectly either by means of Yntema's [18] formula or by applying an appropriate conversion factor to elasticities of substitution. The latter alternative is seldom employed, being vulnerable to serious criticisms at both the theoretical and empirical level.⁵ Yntema's formula has however been used by Balassa [2] and others to estimate import price elasticities when direct estimates are absent. As yet, no direct comparison between direct and indirect estimates has been made. It may therefore be judged a useful exercise to compare direct and indirect estimates using Irish data. The latter will also serve as a convenient counter check on our direct estimates.

Yntema's formula is as follows:⁶

$$(1.7) \quad \pi_m = P/M\epsilon + C/M\pi$$

π_m = price elasticity of demand for imports
 π = domestic price elasticity of demand for importables
 (imports plus domestically produced substitutes)
 ϵ = domestic price elasticity of supply of domestic
 production
 P = domestic production of importables
 C = domestic consumption of importables
 M = total imports.

The usefulness of this formula is not immediately apparent since estimates of ϵ , π , P/M and C/M would appear no less difficult to obtain than direct estimates of the import elasticities themselves. However, if certain simplifying assumptions are made, elasticity estimates may be obtained quite easily from the (1.7) formula.

5. Criticisms date from MacDougall's [13] pioneering work on the subject in the early 1950's. It was pointed out, first that substitution elasticities are themselves difficult to estimate correctly (the analysis requires the assumption of equal income elasticities for and supply elasticities of each country's exports—the well-known symmetry assumption) and secondly that to convert a substitution elasticity into a demand elasticity further restrictions are required. We must, for example, assume zero cross-elasticities of demand between a country's exports and domestic production of the importing country—an assumption which runs counter to one of the basic postulates of international trade theory. For further details, see Harberger [5].

6. The proof may be found in Yntema [18, 43-45] or Kreinin [11, 514].

For example, assuming $P/M = C/M$ and $(\pi + \epsilon)$ the same for all countries, Balassa derives estimates for a number of countries with the aid of data on P/M from input-output tables and directly calculated elasticities of U.S. import demand at a disaggregated level. Thus, for example, π_m for U.S. finished manufactures imports is directly estimated to be -4.12 and P/M is equal to 4. This implies $(\pi + \epsilon) = 1.03$. To derive a comparable elasticity estimate for, say, Canada, use the formula:

$$\begin{aligned}(\pi + \epsilon)P/M &= \pi_m \\ 1.03 P/M &= \pi_m\end{aligned}$$

Given $P/M = 2$ in Canada, $\pi_m = -2.06$. And so on for other countries.

In Ireland's case, P/M may be defined in one of two ways: (a) value added in manufacturing divided by manufactured goods imports (sections 5 to 8 of the UN SITC), (b) gross domestic output of transportable goods industries divided by total imports (less material inputs for use in agriculture). Definition *a* has been used by Balassa and others. Definition *b* although formally correct, will tend to overestimate the true elasticity since the assumption of perfect substitutability between imports and domestic goods on which the formula is based cannot be expected to apply in Ireland's circumstances. In the absence of estimates of π and ϵ , we follow Balassa and other in assuming they are equal to those of the United States. Two sets of elasticity estimates are thus derived (see Table 3), one set corresponding to definition *a*, the other to definition *b*. The latter may be taken to represent "upper-bound" estimates. For purposes of comparison, Ball and Marwah's directly estimated elasticities for US imports are also included.

In order to establish comparability between our directly estimated elasticities and those of Table 4.2, two steps are required. First, it is assumed that finished manufactures imports consist solely of CG and PCG imports whereas MFP imports include only crude materials and semi-finished manufactures. Secondly, a joint CG and PCG elasticity was calculated by weighting each individual elasticity by its share in total imports in 1966. The two "indirect" elasticities, crude materials

TABLE 3: Price Elasticities of Demand for Ireland of Selected Import Categories using the Indirect Method

Description	Ireland <i>a</i>	Ireland <i>b</i>	US
Crude Materials	0.09	0.13	0.39
Semi-finished Manufactures	0.38	0.55	1.63
Finished Manufactures	0.96	1.37	4.12

Note: Definition *a*, $P/M = 0.93$. Definition *b*, $P/M = 1.33$.

Implicit values of $(\pi + \epsilon)$ are 0.10, 0.40, 1.03 for crude materials, semi-finished manufactures and finished manufactures respectively. Elasticities are expressed in absolute values (i.e. without minus signs).

TABLE 4: Comparison of Import Price Elasticities Calculated by Direct and Indirect Methods of Estimation

	Direct		Indirect	
	Lower Bound	Upper Bound	a	b
Materials for Further Production	0.22	0.33	0.27	0.38
Consumer and Producers' Capital Goods	0.97	1.94	0.96	1.37

Note: Elasticities are expressed in absolute values (i.e. without minus signs).

and semi-finished manufactures, were similarly combined to obtain an elasticity directly comparable with the MFP elasticity. The results are recorded in Table 4.

The close correspondence between the two sets of estimates may occasion some surprise in view of the rather extreme assumptions on which the indirect estimates are based. The only significant disparity arises in the case of the upper bound elasticities of CG and PCG imports. The indirect upper bound at -1.37 lies well below the direct upper bound of -1.94 . As it happens, our confidence in the directly estimated price elasticities of PCG and CG imports is not particularly strong. It was pointed out in our study [12] that a deliberately wide range of elasticities was being taken for CG goods in order to indicate the degree of uncertainty attaching to these estimates. It is encouraging to note that the direct lower bounds estimate is much the same as the indirect estimate. Our comparison between direct and indirect estimates, therefore, appears to provide encouraging support for those economists who, owing to the absence of directly calculated elasticities, are (or were) obliged to resort to the indirect method.

Conclusion

Three methodological issues relating to import demand have been discussed in this article: the usefulness of disaggregation, the sensitivity of elasticity coefficients to differences in the specification of the import demand equation, and the relation between "direct" and "indirect" price elasticity estimates. Our conclusions may be summarised briefly.

Disaggregation, it was seen, cannot be relied on to counteract the aggregation bias attaching to the price coefficient of import demand equations. Disaggregation is, however, useful as a counter check on aggregate projections. If prices of goods with different elasticities are changing in a predictable fashion, then disaggregate equations may well yield superior results to the aggregate equation. Disaggregation would also be desirable if the structure of imports were changing, with

different income/output elasticities associated with each import component. It was shown that equivalence between the aggregate and combined disaggregate elasticities does not imply that the two sets of elasticities will provide the same import projections.

In recent years a number of different import demand models have been developed by Houthakker and Taylor [6], Houthakker and Magee [8], Turnovsky [17] and others. By taking account of stock variables and by allowing for lagged adjustments to price and income changes, these models present a much more satisfactory and credible representation of import demand than the simple and unsophisticated "static" equations often used in import elasticity estimation. It was seen, however, that the reduced form of these models is often compatible with more homely hypotheses and fails to reflect to subtleties of the underlying theory. Consequently, one may find that the elasticities derived from "static" and "dynamic" equations differ hardly at all. This certainly was the case in our empirical study of Irish import demand. We concluded that, with the improvement in the quality and range of data, more sophisticated empirical tests will hopefully be applied to the dynamic import demand models. Furthermore, there is a need for more research into the lag-structure of import demand—for example, much useful work on investment demand functions could, and doubtless will in future, be applied to demand functions for capital goods imports.

Import price elasticities have been calculated via the "indirect" method by a number of authors but no comparison between direct and indirect estimates has hitherto been made. Our results indicate a degree of conformity between the two sets of elasticities which, in view of the different assumptions underlying each method of estimation, may strike one as surprising. It may also offer some reassurance to those who are obliged to resort to the indirect method in the absence of directly estimated elasticities. The indirect method is simple to apply and may be used to check that the order of magnitude of direct elasticities is correct.

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