MEASURING THE UK ECONOMY'S ARMINGTON ELASTICITIES

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Abstract

In this paper, Armington elasticities, defined as the elasticities of substitution between imported and domestically produced goods, are econometrically estimated for the United Kingdom. These elasticities are intended for use in the GTAP computable general equilibrium model of world economy. Armington elasticities are critical parameters for such models but are rarely estimated empirically. With such reliance on general equilibrium models to inform policy, we want to determine how reliable such GTAP parameters are. With elasticities in the range of 0.001 to 2.692, the results of this paper suggest that the GTAP parameters of Armington elasticities are too high for an economy such as the United Kingdom. Thus, leading us to conclude that the GTAP model, with its current parameters, may inflate the gains from trade resulting from trade liberalisation.

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"Modelers must know general-equilibrium theory so that their models have a sound theoretical basis; they must know how to solve their models; they need to be able to program (or at least communicate with programmers); they have to know about data sources and all their associated problems; and they have to be conversant with relevant literature, *especially that on elasticities*." Shoven & Whalley (1984).

1. Introduction

Since the mid-80s, applied general equilibrium (AGE) models have been used to analyse various trade and investment policies by estimating and explaining international trade flows and their welfare implications. AGE models have measured economic effects of changes to trade policy, resource allocations within countries, custom union and trade negotiation issues, as well as environmental impacts from trade. In AGE modelling, changes in policies need to be converted into price effects which, in turn, will determine how these policies impact various variables of interest such as output, income levels, trade flows and economic welfare. AGE models of international trade such as the Global Trade Analysis Project (GTAP) rely on parameters, endowments (labour, capital, land etc) and trade data to generate price and welfare effects. Since the endowments and trade data are easily quantifiable, the results of AGE models are largely determined by the choice of the behavioural parameters, most of them elasticities, which reflect the sensitivity of consumers and firms to changes in relative prices.[3] However, the measures of these elasticities are generally not identified with precision and very little is known about what determines their value. Furthermore, many AGE models assume these elasticities to be the same for each country, even though in reality they are based on preferences and it is likely that preferences would vary across countries[4]. Ideally, elasticities should be generated by statistical or econometric methods based on the historical behaviour of prices and quantities and then examined for consistency with economic theory and analysts' intuition.

[3] An elasticity is defined as the percentage change in a variable Y induced by a one percent change in a variable X, all other things being equal.
[4] See Welsch, 2008.

In AGE models, the dynamic relationships between policy changes, price effects and economic effects are largely determined by an important assumption: the Armington.[5] More specifically, the Armington assumption determines the behavioural relationship between the demand for the foreign (imported) and domestic goods considering their relative prices. The defining property of the Armington assumption is that goods are considered homogeneous except for their country of origin thus implying that consumers value goods differently according to where the good was produced. This assumption leads to the crucial possibility of two-way trade of a good between countries. Any model based on the Armington assumption "includes intra-industry trade with the intention to reflect actual international trade patterns more accurately" (Armington, 1969).

The Armington assumption is represented in AGE models by the macro and the micro Armington elasticities of substitution. The *macro-elasticity* determines the degree of interchangeability in demand between foreign and domestic good varieties. Goods with a *high macro elasticity* are goods for which consumers will *substitute relatively easily* between domestic and foreign varieties given a relative change in domestic and foreign prices. On the other hand, goods with a *low macro elasticit*y imply that consumers stay with their preferred variety more firmly as they strongly distinguish goods according to their origin (*less willing to substitute* between the two). For example, the macro Armington elasticity of substitution between relatively homogenous agricultural (rice, wheat, meat) or mining products (oil, gas) would be expected to be higher than that between bundles of differentiated manufactured goods (beer, wearing apparel). The *micro-elasticity* reflects the second-tier choices between suppliers of the imported good (at the country level).

According to our knowledge, no set of comprehensive Armington elasticities (macro or micro) of substitution have previously been measured for the United Kingdom (UK). Some calculations have been made for the European Union countries (of which some

[5] See Armington, 1969.

included the UK)[6] or for certain UK sectors but not for the entire UK economy[7]. Thus, when doing AGE modelling, we currently rely on the GTAP sets of behavioural parameters which applies the same Armington elasticities across countries[8]. As per McDaniel & Balistreri (2003): the outcomes of AGE trade models are sensitive to the size and variations of Armington elasticities thus the quality of measurement of these parameters can greatly affect modelling results. To illustrate the importance of these estimations in understanding the trade dynamics of the UK Economy, we look at quantitative and qualitative arguments by running an AGE model and by looking at the current literature, respectively.

The quantitative importance of the Armington elasticities in AGE models can be demonstrated by computing two UK trade policy scenarios: 1) unilateral tariff reduction[9] and 2) a 10% rise in tariffs[10]. Using the static GTAP CGE model[11], we measure the impacts on GDP and terms of trade (TOT) holding the response of the other regions constant. Under scenario 1, with low macro Armington elasticities, 1 and 3[12], (the long-run time-series econometric estimates of Gallaway, McDaniel & Rivera, 2000) the UK would see its GDP reduced by -1.141% and -0.332%, respectively. Adopting a higher estimate, for example 5, (in the range of Hummels, 1999) would then predict that the same liberalisation scenario still hurt the UK economy (-0.104% growth of GDP). Only under a macro elasticity of 6 we find that unilateral liberalisation brings positive UK GDP gains of 0.003%. Under scenario 2, a 10 percent rise in tariffs and low macro Armington elasticities of 1 and 3, the UK would see its TOT increase by 0.068% and 0.027%, respectively. Adopting the elasticities of 5 and 6 would increase the UK TOT by 0.020% and 0.019%. These two simple modelling exercises demonstrate that the quantitative effects of liberalisation are quite sensitive to the

[6] See Huchet & Pishbahar, 2008; Nemeth, Szabo & Ciscar, 2011; Oleyseyuk & Schurenberg-Frosch, 2014, Aspalter, 2014.
[7] See Welsch, 2008; Mijnen, 2013.
[8] For further details, see Chapter 14: Behavioral Parameters, GTAP model, Purdue University.
[9] We follow the example of McDaniel & Balistreri (2003) and apply various elasticities within the range of the literature.
[10] See Zhang (2006) for a complete analysis of the terms of trade impact of such increase in tariffs.
[11] We use the RunGTAP model version 3.70 with the GTAP10 database. The model is developed and maintained by the Purdue University. We also change the closer rule to allow capital to move between regions.
[12] In the simulations, the same elasticity is applied across the entire set of GTAP sectors and we maintain the ratio of 2 between the lower-tier (import sources) and the upper-tier (macro) elasticities.

choice of elasticities and confirms the potential issue of biased AGE results due to a misspecification of these parameters (inflating or deflating the gains from trade).

The current literature on Armington elasticities suggests that there is value in estimating a UK-specific set of elasticities: First, the majority of existing studies provide results only for the United States (US) (with sizeable variations between them) and the few studies available for other countries find considerably different results (Olekseyuk & Schurenberg, 2014). Second, Armington elasticity estimates can be sensitive to the choice of estimation strategy (Feenstra *et al.*, 2014) and third, they need to be measured on a disaggregated sectors level (Ossa, 2015)[13]. Finally, one of the biggest breakthroughs in the recent trade literature is the Arkolakis *et al.* (2012) formula for computing welfare gains from trade. It demonstrates that welfare or gains from trade can be measured irrespective of a quantitative model, by simply looking at the change in the share of domestic expenditure and the *trade elasticity*. It thus highlights the fact that even when abstracting from AGE or other models used for measuring the impacts of trade policies, the Armington elasticities are at the core of any valuable analyses and should be measured accordingly. We believe that to understand better the trade responses of the UK economy to change in prices and/or tariffs, estimating these parameters is essential.[14]

In this paper, we propose to measure the macro Armington elasticities reflecting the domestic and trade structure of the UK economy. Following Blonigen and Wilson (1999), Kapuscinski & Warr (1999) and Gallaway, McDaniel & Rivera (2003), we assess the *sizes* of the macro Armington elasticities. Using historic data from the Office of National Statistics (ONS), from Her Majesty's Revenue and Customs (HMRC) and from the Department for Environment, Food and Rural Affairs (DEFRA), we produce Armington elasticities for UK agricultural and manufacturing industries defined at the GTAP10 sectors level.

[13]Ossa (2015) demonstrates that accounting for differences in elasticities across industries greatly increases estimates for welfare gains of trade compared with single-sector models that do not differentiate between industries

[14] Calculating these elasticities are even more important in the case of a small economy as the optimal tariff is inversely related to the Armington elasticity. See McDaniel & Balistreri (2003).

The remainder of the paper is divided in six sections. Section 2 reviews the literature. Section 3 highlights the methodology. Section 4 describes the estimation procedure. Section 5 discusses the data. Section 6 presents the results and section 7 concludes.

2. Literature review

2.1. The Armington assumption

Standard trade theory only focuses on inter-industry trade: if a country trades a good, it either exports it or imports it. In any case, it does not both export and import the same good. This means that two-way trade (or intra-industry trade) is ignored in standard trade theory. In the reality, countries frequently export and import the same good, so to obtain more realistic results in trade modelling, Paul Armington, in 1969, postulated the assumption that firms in each region produce a unique variety of a good. As a result, goods produced in different countries are imperfect substitutes in demand and the number of varieties is therefore equal to the number of regions. Intra-industry trade is reflected in that these unique varieties can be exported to and from trading countries rendering the Armington model better suited to reflect actual international trade dynamics[15].

The Armington assumption is represented by two substitution elasticities: the macro and the micro. The macro elasticity reflects substitution between goods produced domestically (home) and imported (foreign) goods[16] and the micro elasticity looks at substitution for the same imported goods provided by different foreign suppliers. Both Armington elasticities are essential to AGE modelling, but the focus of empirical research has been almost exclusively on the macro elasticity mostly due to the greater difficulties and data requirements involved in estimating micro elasticities.[17]

[15] The Armington assumption has become the fundamental basis of any AGE models.
[16] See (Feenstra *et al*., 2010) for a comprehensive discussion on the substitution effect.
[17] There has been increasing research on estimations of micro elasticities and results support the assumption of them being larger than macro elasticities (Feenstra, 1994; Broda & Weinstein, 2006; Corbo & Osbat, 2013).

In most AGE models, the macro Armington elasticity is derived from a three-stage budgeting process[18]: In the first stage, the representative agent allocates his income to different consumption products. In the second stage, following a constant elasticity of substitution (CES) function, the representative agent further allocates expenditure for each product between foreign and domestic product (Blonigen & Wilson, 1999). The micro Armington elasticity is the third stage which determines the foreign source (country) of imports.

2.2. The size of the Armington elasticities[19]

Because it governs the strength of the relative demand response to relative international prices, the sizes of the Armington elasticities are crucial to our understanding of the global trade dynamics resulting from a change in policy. The extent to which a policy change will affect a country's trade balance, production, GDP and welfare all depend on the measured size of the Armington elasticity used in modelling thus rendering essential the estimation of these parameters (Feenstra *et al.*, 2010).

The earlier estimations of trade elasticities go back to 1976 with Stern *et al.* where the authors provide the first set of import-demand elasticities for 28 industries. According to McDaniel & Balistreri (2003), three subsequent studies have attempted to capture Armington elasticities for the US imports of various goods using linear regression methods: Shiells *et al* (1986), Reiner & Roland-Holst (1992) and Shiells & Reinert (1993). Despite the fact that these studies employ sound approaches to Armington estimation, these earlier sets of elasticities were assumed to be too low (domestic and imported goods are believed to be more substitutable than the estimates would suggest) as they generated unrealistically large terms of trade. For example, Shiells *et al* (1986) using US data for the period 1962-78 and partial equilibrium demand systems relating changes in prices to changes in trade flows, estimated elasticities of 0.45 to 6.5. Studies from this time include that of Lachler (1985) who found Armington

[18] The representative agent will consume according to his utility function defined over composite goods which are composed of imported goods and domestic goods.
[19] See Mijnen (2013) for a summary of empirical studies on Armington elasticities.

elasticities of between 0.8 and 4.9 for 23 German industries and Shiells & Reinert (1993) who obtained Armington elasticities of between 0.14 and 1.98.

More recently there have been a few studies involving more complex estimation models such as Hummels (1999) and Gallaway, McDaniel & Rivera (2003) in which the authors find values that are significantly higher than those found in older studies. However, these types of studies remain few and their results are far from consistent among them. For example, to generate elasticities applicable to the general equilibrium structure of an AGE, Hummels (1999) exploits cross sectional data rather than time series data. He estimates trade costs using data on freight costs and model-implied estimates from a gravity equation and then estimates elasticities using variations in imports and trade costs across countries.[20] He finds ranges of 2 to 5.3 for Armington elasticities. Gallaway, McDaniel & Rivera (2000) produce a disaggregated set of Armington elasticity estimates by considering the long run aspect inherent to AGE modelling. Looking at 309 industries at the ISIC 4 level for 1989 to 1995 they find elasticity ranging from 0.52 to 4.83. Their study also confirms an important aggregation bias: the greater the ease of substitutability comes from the more detailed the commodity level.

These results highlight the important fact that the Armington elasticities used in AGE models generally differ substantially from the ones measured empirically. For example, the average GTAP macro elasticities are set at 3.1, which is substantially higher than the macro Armington elasticities found in most empirical studies. Gallaway, McDaniel & Rivera (2000) infer that AGE modellers are aware of the empirical results but that they believe them to be too low thus generating unrealistically low levels of trade and prefer to neglect them. Some authors argue that differences in Armington elasticities stem from the variations in model specifications between AGE modelling practices and the econometric approaches used to obtain estimates for the Armington elasticities (McDaniel & Balistreri, 2003)

[20] These studies highlight the importance of estimating elasticities in a method consistent with the model for which the elasticities are being measured.

Empirical studies unambiguously show that micro Armington elasticities are higher than macro Armington elasticities (Nemeth, Szabo & Ciscar, 2011, Feenstra *et al*, 2014). This implies that it is easier to substitute between two foreign goods than it is to substitute between a domestic and a foreign good. Intuitively this makes sense if we account for a home-bias factor which makes consumers favour home products over foreign products. These results are generally accepted in AGE modelling practices as well. In GTAP for example, all micro-elasticities are twice that of the corresponding macro elasticity.

In summary, when trying to define the size of Armington elasticities, authors of empirical studies have attempted to estimate these elasticities for individual countries and/or sectors. Most of these studies have found macro Armington elasticities close to or less than one (Reinert & Roland-Holst, 1992; Shiells & Reinert, 1993; Blonigen & Wilson, 1999; Sauquet *et al,* 2011). Interestingly, AGE modellers generally use macro elasticities that are substantially larger than those found by empirical studies and, in the words of Welsch (2008), are often based on 'guestimations'. McDaniel & Balistreri (2003) state that much of the controversy surrounding Armington elasticity estimates arises from structural differences between econometric models used to measure Armington elasticities' size and the AGE models used to evaluate policy.

2.3. New New Trade Theory

One of the findings that most directly influenced the development of the theoretical trade literature is that of extensive margin growth and redistribution of inputs among firms. Specifically, after a country undergoes trade liberalisation, some of the firms that previously served only the domestic market begin exporting while others cease production entirely. Hummels & Klenow (2005) measure the extensive margin for 126 exporting countries and find that it accounts for approximately 60 percent of the greater exports of larger economies.

Inspired by these empirical studies of how firms react to trade liberalization, the trade literature developed theoretical models to help us understand the origins and implications of these newly discovered patterns. The most influential of these new models were the Melitz (2003) model of firm heterogeneity with monopolistic competition and trade, and the multidimensional Eaton & Kortum (2002) model of perfect competition and international trade. Arkolakis *et al.* (2012) show that these new models are equivalent to the older Armington models in the sense that their welfare predictions depend only on the trade elasticity and the change in domestic trade shares. Simonovska & Waugh (2012) show, however, that despite identical predictions for changes in trade flows for a given fixed trade elasticity and shock to trade costs, the models have different implications for how trade elasticities should be estimated.

3. Methodology

McDaniel & Balistreri (2003)'s literature review provides an interesting starting point for identifying robust findings that allows us to customise our methodology. First, long-run estimates are higher than short-run; second, the level of aggregation is important, with the more disaggregate the sample, the greater the estimated substitution elasticity; Third, recent cross-sectional studies find higher substitution rates than the central values obtained in the time-series studies. Considering these findings, we estimate the UK's macro Armington elasticities by:

1) Measuring both long-run and short-run estimates.[21] Given that most trade policy analysis focuses on a long-term horizon for modelling, these long-run estimates will be most valuable. As highlighted by Cassoni & Flores (2008) and McDaniel & Balistreri (2003) and demonstrated by Feenstra *et al* (2014), we measure long run estimates in order to match the time horizon of our macro-Armington elasticities with the time horizon of our AGE model (about 15 years). Using short-run estimates in AGE has the potential to understate the modelled trade response. However, short-run estimates are useful as they enable us to additionally assess the sensitivity of this impact in the near-term horizon.

[21] It allows for comparison of our results with those of Gallaway, McDaniel & Rivera (2003) on the relative size of both types of estimate.

2) Assessing a level of sectors/industries aggregation which matches the number of sectors in our AGE model.[22] Empirically, it is found that the more disaggregate the sample, the greater the estimated substitution elasticity. Considering this, it is important to question common practice in flexible aggregation models of applying aggregate estimates of the Armington elasticities to individual sectors that are the focus of study and/or applying the average elasticity from disaggregate estimates to an aggregated commodity. We feel that it is important for modelers to consider these known biases and not to adopt econometric point estimates indiscriminately. This underlines our effort to measure empirically grounded estimates for a level of detail that is consistent with the 65 sectors breakdown in the GTAP 10 AGE model.

3) Ensuring that our estimation models are consistent with the economic theory of Armington models and present a range of econometric specifications. According to McDaniel & Balistreri (2003), “the specifications of Stern, Francis, & Schumacher (1976), Shiells, Stern & Deardorff (1986), Reinert & Roland-Holst (1992), and Shiells & Reinert (1993), and Gallaway, McDaniel & Rivera (2000) all suffer from the general critique that they are structurally inconsistent with the general equilibrium because they do not give adequate consideration to the supply side of the market”. Even the results of Hummels (1999) and Erkel-Rousse & Mirza (2002), produced under the specification of monopolistic competition, should only be prudently applied to most AGEs of perfect competition and constant returns to scale.

Mindful of these requirements, we follow the approaches of Blonigen & Wilson (1999), Kapuscinski & Warr (1999) and Gallaway, McDaniel & Rivera (2003) to estimate the sizes of the UK macro Armington elasticities. [23]

4. Estimation procedure

[22] This will allow us to address one of the concerns of previous studies: empirical estimates were judged too small.

[23] Blonigen & Wilson (1999) use a two-stages estimation procedure to measure the size of the Armington elasticities and their determinant. We only use the first stage in this paper.

Conceptually, Armington models are derived from the solution to the consumer's optimisation problem using a CES utility function to describe the choice between domestic goods and foreign goods. In practice, due to data availability, we assume that all domestic purchasers of a certain good are identical in their demands and in their assessment of the substitutability of imported and domestic supplies. The categories of domestic demand include final consumers, intermediate good purchasers, investment good purchasers and the government.[24] Following past literature, we solve this consumer's optimisation problem to derive an equation which links relative market shares of domestic/foreign goods to their associated relative prices via an elasticity of substitution. This allows theoretically consistent estimation of the Armington elasticities.

For estimation model specifications, we then follow the econometric approaches of Blonigen & Wilson (1999), Kapuscinski & Warr (1999) and Gallaway, McDaniel & Rivera (2003) and estimate the elasticities using three models: Ordinary Least Squares (OLS), Partial Adjustment Model (PAM) and the Error Correction Model (ECM). The three papers present the foundations for the OLS model whereas the second and the third paper provide the fundamentals for the PAM and the ECM.

4.1. Deriving a Theoretically Consistent Form for the Estimation Equation

Following Armington (1969), it is assumed that the consumer's utility function for goods in one industry is separable from that for other products and implies the CES sub-utility function (1) to model demand for domestic and imported goods in that industry:[25]

$$U(M,D) = \left[\beta M^{\frac{(\sigma-1)}{\sigma}} + (1-\beta) D^{\frac{(\sigma-1)}{\sigma}}\right]^{\frac{(\sigma)}{\sigma-1}} \tag{1}$$

Where *U* is the sub-utility over the domestic and the foreign good, *M* is the quantity of the imported good, *D* is the quantity of the domestic good, β is a share parameter that

[24] Due to a lack of detailed data, empirical studies must rely on data relating to the aggregate demand for imported and domestically produced forms of individual goods, without distinguishing among the various levels of domestic demand.

[25] The representative consumer obtains utility from a composite good of domestic (D) and imported (M) goods and we assume that there are continuous substitution possibilities between the two.

weights the imported good's utility relative to that of the domestic good[26] and σ is the constant elasticity of substitution between the domestic and the imported good. Using this utility function to solve the consumer's optimisation problem, allows us to derive the following first-order condition:

$$\frac{M}{D} = \left[\left(\frac{\beta}{1-\beta}\right)\frac{P_D}{P_M}\right]^{\sigma} \tag{2}$$

Where P_D and P_M are the price of the domestic and the imported good, respectively. Taking the logs of (2) yields (3) as the general form of the model to be estimated:

$$\ln\left[\frac{M}{D}\right] = \sigma \ln\left[\frac{\beta}{(1-\beta)}\right] + \sigma ln\left[\frac{P_D}{P_M}\right] \tag{3}$$

In equation (3), $\sigma ln\left[\frac{\beta}{(1-\beta)}\right]$ is a constant which hold no practical relevance. Thus, the equation simplifies to (4) where the estimated coefficient on the log of the price ratio gives a theoretically grounded estimate of the Armington elasticity in a sector.

$$\ln\left[\frac{M}{D}\right] = \alpha + \sigma ln\left[\frac{P_D}{P_M}\right] \ + \mu \tag{4}$$

The σ parameter describes the extent to which the two types of good can be substituted for one another. As σ approaches a value of infinity, this is an indication that the goods are perfect substitutes, whilst a value of σ approaching 0 indicates that the goods are perfect complements. Intermediate values of σ that approach 1 result in the classic Cobb-Douglas utility function where goods are imperfect substitutes for each other.

To operationalise this equation and allow for estimations the UK elasticities, we need to properly address the dynamics that are present in the data series. Taking these

[26] The parameter β can be thought of as reflecting the degree of home bias for an industry's specific goods.

dynamics into consideration ensures that the estimated parameter on $ln\ (P_{D,t}/P_{M,t})$ successfully isolates σ and does not suffer from bias. To achieve this, we turn to three model forms, referred to as OLS, PAM and ECM respectively that have precedent in the literature. An important factor in addressing the dynamics of the data series is whether the series display cointegration. We find that series vary by whether they are stationary or integrated processes. Consequently, the first two models are useful in cases that series are both stationary, whereas the ECM model is also useful for addressing cases where the series are jointly cointegrated.

4.2. Ordinary Least Squares (OLS) model

This specification has been used in most of the literature on quantifying Armington elasticities[27].

$$ln\ (M_t/D_t) = \alpha_0 + \alpha_1 ln\ (P_{D,t}/P_{M,t}) + \boldsymbol{\alpha_2 Z_t} + \mu_t \qquad (5)$$

To address the potentially seasonal nature of trade when using monthly data, a set of monthly dummy variables, $\boldsymbol{Z_t}$, is included in the estimation specification.[28] As per Kapuscinski & Warr (1999) and Gallaway, McDaniel & Rivera (2003), the static nature of equation (5) means that it may not yield optimal estimates of the elasticity. By excluding dynamics, the OLS model cannot capture the dynamic relationships between imports, domestic production and price that may result if the quantity response to price changes is not completed in the timeframe of the single observation. Despite being an assumption in comparative-static modelling, that prices and quantities adjust instantaneously to a given exogenous change, the actual change may take some time due to factors such as consumption patterns, trade in intermediate goods and existing inventory levels. This implies that it is therefore important to include variables describing the dynamics of the adjustment period to avoid biased and inconsistent estimates of elasticities.

[27] Mijnen (2013), Blonigen & Wilson (1999), Gallaway, McDaniel & Rivera (2003) and Kapuscinski & Warr (1999), Hertel *et al* (1999), to list a few.

[28] These are used for manufacturing sector estimates where the data used is monthly. For agricultural sector estimates, where data is annual, no dummies are used.

4.3. Partial Adjustment Model

One method of overcoming the problem of incomplete adjustments in the markets relies on estimating a *Partial Adjustment Model (PAM)*:

$$ln\ (M_t/D_t) = \alpha_0 + \alpha_1 ln\ (P_{D,t}/P_{M,t}) + \alpha_2 ln\ (M_{t-1}/D_{t-1}) + \alpha_3 \mathrm{Z_t} + \mu_t \qquad (6)$$

Here the estimated short run value of elasticity is given by the estimate of α_1. Whereas long run estimates can be estimated as α_1/(1-α_2). Such a specification can be derived from the assumption that the dependent variable adjusts towards its series mean at a constant proportion of the present period's deviation from the mean.

4.4. Error Correction Model

As is shown in Engle & Granger (1987), if two data series are cointegrated, there exists an error-correction model (ECM) representation of the variables. As an alternative method of overcoming the shortcomings of model (5), Kapuscinski & Warr (1999) and Gallaway, McDaniel & Rivera (2003) suggest using an ECM to estimate Armington elasticities.

Error-correction models often take the following form:

$$\Delta ln\ \left(\frac{M_t}{D_t}\right) = \alpha_0 + \alpha_1 \Delta ln\ \left(\frac{P_{D,t}}{P_{M,t}}\right) + \alpha_2 \left(ln\left(\frac{M_{t-1}}{D_{t-1}}\right) + \alpha_3 ln\left(\frac{P_{D,t-1}}{P_{M,t-1}}\right)\right) + \alpha_4 \mathrm{Z_t} + \mu_t \qquad (7)$$

Where $\Delta ln\ (M_t/D_t) = ln\ (M_t/D_t) - ln\ (M_{t-1}/D_{t-1})$ and $\Delta ln\ (P_{D,t}/P_{M,t}) = ln\ (P_{D,t}/P_{M,t}) - ln\ (P_{D,t-1}/P_{M,t-1})$ and where the short run elasticity estimate is provided by α_1 and the long run elasticity estimate is α_3.

Equation (7) shows a standard formulation of the ECM. However, the model can be augmented with additional lags of both the independent and dependent variable if this captures important dynamics present in the data. Due to the importance of capturing these dynamics, discussed above, we include two sets of ECM estimates in our results. The first matches equation (7) to allow comparison to previous estimates in the literature which use that specification. The second selects the optimal lags of the independent and dependent variable to maximise the Bayesian Information Criterion often used in time series models to select optimal specification.

5. Data

Following the data construction procedure of Reinert & Roland-Holst (1992); Gallaway, McDaniel & Rivera (2003) and Kapuscinski & Warr (1999), we require data on domestic sales, domestic prices, imports and import prices.

5.1. Domestic Sales and Domestic Prices

5.1.1. Agriculture

Data on the sales of UK agricultural industries are created by the UK's Department for Environment, Food, & Rural Affairs (DEFRA) and are available at a breakdown in line with the EU's Economic Accounts for Agriculture (EAA). Since, the data is not broken down by domestic and foreign sales, we obtain domestic sales by subtracting the total value of exports from the total series (for each relevant GTAP sector).

DEFRA produces Agricultural Price Indices (APIs) to reflect the price of UK agricultural goods on a comparable sector basis to its sales data. Again, we use this as a measure of price for each sector as well as to deflate data on sales to get a measure of real quantities sold.

Purdue University's GSC3 sector classification does not contain a mapping for agricultural sectors to the ISIC sectors that the EAA is based upon. Therefore, an effort is made to concord the data that is available to GTAP sectors using the descriptions of sectors contents that are available. This means there is a likely a degree of disparity between the goods that included in domestic sales data and in imported goods sales data. As DEFRA's data covers all major agricultural sectors, this is related to the issues of aggregation mentioned above that heterogeneity in the products that underlie each

GTAP sector means that not all products included in a sector will be available in both import and domestic form. This is no immediate solution to this problem, however as the majority of UK trade is covered, this should not be an issue. In extreme cases however, the UK does not produce any notable output in certain GTAP sectors such that estimates cannot be obtained for these sectors.[29]

Where multiple data series for prices are included in a GTAP sector, Laspeyres indices are calculated for the total sector using the data on sales as a weight. Annual data is available for sales and prices from 1995 onwards.

5.1.2. Manufacturing

Data on the sales of UK manufacturing industries are created by the UK's Office for National Statistics (ONS) and are available as turnover by SIC industry. The ONS splits turnover into domestic sales and sales abroad. To reflect the fact that the Armington model reflects the choice of UK consumers buying UK or foreign goods, we use the data series for domestic sales only.

To measure the price of these domestic sales, the ONS creates Producer Price Indices (PPIs) on the same SIC sector basis. We use this as a measure of price for each sector as well as to deflate data on sales to get a measure of real quantities sold.

These are concorded to GTAP sectors using Purdue University's GSC3-ISIC Rev.4 concordance.[30] Both sales and price data are available on a monthly basis for the period since 1999.

[29] Examples include GSC1-Rice and GSC7-Fibre Crops. As this is a reflection that the UK does not produce these goods, this means that the choice between domestic and foreign alternatives is redundant in any case.

[30] https://www.gtap.agecon.purdue.edu/databases/contribute/concordinfo.asp

5.1.3. Services

The availability of services data makes extending the analysis to GTAP's 20 services sectors difficult. This is particularly the case with data on the price of the imported services where the difficulty defining the unit of services means calculating unit value indices from the import data is not an option. However, we have identified a potentially viable solution to use data which is available and, working with the UK's ONS, we are hoping to obtain the necessary data that will allow us to include services estimates in any future publication of our work.

5.2. Import Sales and Import Prices

ONS does not report comprehensive import price indices by sector thus, we produce unit value indices from data on the UK's imports. Whilst we acknowledge the recognised issues with using these kinds of indices, as detailed by International Monetary Fund (2009) and others, the lack of alternative price indices based on survey data and the precedent in previous Armington studies indicates that this approach offers the most effective option.

Data for elementary value indices are extracted on a HS 6-digit basis from HMRC data on monthly UK imports. An effort is used to use unit quantities for dividing each series but where this is not reliably and consistently available, the weight of imported goods is used instead. Where HS codes have changes over the previous 20 years, mappings are made between different series. In some cases where a 6-digit code splits into multiple codes, this involves aggregating series to produce a consistent series. These elementary indices are then aggregated into total import price indices for each GTAP sector using Laspeyres indexes with import values for each 6-digit series being used as a weight. To reflect the seasonal variations in imports, the weight used is total year import values for the first year of the data used.

For import sales data, the total value of each series is summed for each GTAP sector in each period. This is then deflated by the import price index constructed for each sector above to give data series on the real quantity of sales.

Data is available for the same period as domestic prices and sales. However, in cases where mapping 6-digit series to the pre-2002 HS nomenclature or post-2017 HS presents issues that would require greater aggregation of the elementary series, a judgement is made as to whether the granularity of the price data takes is more desirable to additional observations.

5.3. Structure of the UK Economy

To demonstrate relative importance of certain Armington elasticities, we present data on the specific structure of the UK economy which shows the dominance of services sectors. Table 1 provides an overview of the relative importance for total consumption of each commodity of domestic production and import supply. As we can see, three sectors, construction, trade and business services, each contribute in excess of 8 per cent of the total domestic production. Most of the other sectors contribute between 0.01 per cent and 6.0 per cent. On the import side, three sectors also stand out, computer, motor vehicles and business services, with 8.0 per cent each. In most cases, the importance in production does not coincide with importance in imports except for 3 sectors, accommodations (3.5% versus 3.0%), financial (5.1% versus 3.1%) and business services (15.0% versus 8.8%).

Table 1: Summary of the commodity/sector characteristics.

GTAP Sectors	Sector descriptions	Contribution to Production	Contribution to Imports
1-12	Products of agriculture	0.94%	2.13%
13	Products of forestry, logging & related services	0.04%	0.01%
14	Fish & other fishing products	0.06%	0.09%
15	Coal and lignite	0.01%	0.11%
16-17	Crude Petroleum & Natural Gas	0.55%	3.98%
18	Metal Ores	0.25%	0.31%
19-20	Meat products nec	0.55%	1.16%
21	Vegetable oils & fats	0.06%	0.33%
22	Dairy products	0.28%	0.55%

23-25	Food products nec	1.18%	2.72%
26	Beverages and tobacco products	0.43%	2.07%
27	Textiles	0.17%	0.95%
28	Wearing apparel	0.08%	4.07%
29	Leather products	0.03%	1.35%
30	Wood products	0.23%	0.69%
31	Paper products, publishing	0.62%	1.07%
32	Petroleum, coal products	0.62%	3.05%
33	Chemical products	1.03%	4.54%
34	Basic pharmaceutical products	0.56%	4.40%
35	Rubber & plastic products	0.61%	1.98%
36	Non-Metallic Mineral products nec	0.45%	0.81%
37	Ferrous metals	0.44%	3.23%
38-39	Metal products	0.83%	1.67%
40	Computer, electronic & optical products	0.72%	7.78%
41	Electrical equipment	0.38%	3.22%
42	Machinery & equipment nec	0.92%	5.14%
43	Motor vehicles & parts	1.66%	8.85%
44	Transport equipment nec	0.96%	4.96%
45	Manufactures nec	0.65%	3.71%
46	Electricity	2.11%	0.14%
47	Gas manufacture, distribution	1.13%	0.01%
48	Water	1.18%	0.52%
49	Construction	8.23%	0.28%
50	Trade	10.78%	0.23%
51	Accommodation, Food & service activities	3.55%	2.93%
52	Transport nec	1.81%	0.61%
53	Water transport	0.38%	0.57%
54	Air transport	0.64%	1.89%
55	Warehousing & support activities	1.21%	0.24%
56	Communication	2.94%	1.98%
57	Financial services nec	5.12%	3.07%
58	Insurance (formerly isr)	2.09%	0.32%
59	Real estate activities	4.01%	0.20%
60	Business services nec	15.02%	8.79%
61	Recreational & other services	3.51%	2.19%
62	Public Administration & defense	4.74%	0.18%
63	Education	4.04%	0.10%
64	Human health & social work activities	6.36%	0.26%
65	Imputed rents of owner-occupied dwellings	5.81%	0.54%

6. Results

Estimates were obtained from three model specifications: ordinary least squares (OLS), the partial adjustment model (PAM), and the error correction model (ECM), which correspond to equations (6), (7) and (8) above, respectively. These results are presented in Table 2. The first two columns present the OLS results and the PAM results. The last four columns show the ECM results with standard and optimal specifications. For these, we also distinguished between the short-run and long-run estimates of the Armington elasticity. Of the 109 ECM estimates, 44 short-run elasticities were statistically significant and of the right sign, and of the long-run elasticities, 22 were statistically significant and of the right sign.

An interesting point about our results[31] is that they appear to meet all the robust findings of the McDaniel & Balistreri (2003)'s review of the literature as presented in our section 3 on methodology. First, long-run estimates are higher than short-run except for textiles, fabricated metal products and electronic products. Second, the level of aggregation is important, with the more disaggregate the sample, the greater the estimated substitution elasticity. Most of our results have a value of less than one, which corresponds to what might be expected with such a high aggregation level which comes with the GTAP sectors. Third, recent cross-sectional studies find higher substitution rates than the central values obtained in the time-series studies. Our single equation time-series approach is thus expected to produce smaller responses relative to cross-sectional estimations for which there is an inclusion of supply conditions.[32]

Since the results of trade-policy analysis using static computable models are generally interpreted as the long-run effects of policy changes; we discuss the ECM long-run results, when possible. The short run estimates are provided as sensitivity.

Looking at the ECM results, we can see that the average long run elasticity estimates is 0.808, with a range between 0.001 and 2.69. According to our results, some of the most import sensitive sectors are *wheat (wht), oil seeds (osd), raw milk (rmk), lumber (lum)*, *wearing apparels (wap) and transport equipment (otn)*. The less import sensitive sectors would be *textiles (tex), other food products(ofd), vegetables & fruits (v_f), meat products (omt & cmt)* and *rubber & plastics products (rpp).*

A quick comparison with results in previous studies for other economies reveals that our range of estimates are quite acceptable when compared to Reinert & Roland-Holst (1992) for which results range between 0.14 and 3.49; Gallaway, McDaniel & Rivera (2003) for a range of 0.52 to 4.83, and Kapuscinski & Warr (1999) for a range of 0.2 to 4.

[31] We refer to the statistically significant results of ECM and ECM with optimal specifications.
[32] As per Balisteri and McDaniel (2003), time series are structurally inconsistent with the general equilibrium because they do not consider the supply side of the market.

We present our results, on a commodity groups basis starting with agricultural and manufacturing sectors then services.

6.1. Agricultural and resources sectors

Following the GTAP sectoral nomenclature, we estimated Armington elasticities for all agricultural and resources commodities but seven. Due to data availability, we are not able to estimate *paddy rice (pdr)* since the UK does not produce any, and data for *plant-based fibres (pfb)*, *forestry (frs)* and *fishing (fsh) are not complete.* Unfortunately, the resources sectors are subject to a disclosure regulation which made not possible to obtain all the data required to produce the sectors' elasticities. The remaining agricultural sectors are estimated in the short and long run. The range of the long run elasticities goes from 0.13 to 1.69, with an average of 1.12.[33] The sectors with the most responsiveness to a change in prices are *wheat (wht), raw milk (rmk) and oil seeds (osd)* whereas *vegetables & fruits (v_f),* are less responsive.

Overall, estimates for the agricultural sector display a lower degree of statistical significance than estimates for the manufacturing sector do. This reflects the smaller number of observations available for each agricultural sector meaning that estimates likely contain a larger amount of noise. However, in the absence of more frequent data series on agricultural sales, these estimates still give a good indication of the elasticity.

6.2. Manufacturing sectors

Following the GTAP sectoral nomenclature, we measured Armington elasticities for 20 manufacturing sectors out of the 27 sectors forming the manufacturing group. Once again, due to data availability, we could not estimate all the manufacturing sectors elasticities. Our results are presented in table 2.

[33] Our agricultural results are consistent with Donnelly *et al* (2004) and with Kapuscinski & Warr (2015) who find estimates of between 0.02 to 5.0 for agricultural sectors in the USA and the Philippines, respectively.

The range of long run elasticities goes from 0.001 to 2.69, with an average of 0.82. The sectors with the most imports responsiveness to a change in prices are *wearing apparels (wap), lumber (lum)* and *transport equipment (otn)* whereas *other food products (ofd), meat products (omt & cmt)* and *rubber & plastics products (rpp)* are estimated as less responsive.

6.3 Services sectors

Due to the importance of services trade to the UK economy we are looking to extend the analysis to GTAP's 20 services sectors in a future publication. We are currently investigating options for services data that can be used in this analysis.

7. Conclusion

Armington elasticities are central behavioural parameters in any AGE models to determine quantitative and qualitative results that informs policy making. However, the economic literature highlights that there are gaps between the values found in econometric studies and the values used by AGE modellers. As a result, many AGE models simply assume these elasticities to be the same for each country. Furthermore, because most empirical studies on Armington elasticities focus on a single country, such as the US, the variation between countries and sectors has thus far been left almost unexplored. We attempt with this study to fill some of these gaps by measuring the long run macro Armington elasticities representative of the UK economy as per the GTAP sectors.

Overall, our econometrics results suggest that the ECM specification provides an adequate characterisation of the process of substitution between imports and domestic production. Its long-run estimations yield statistically significant estimates of the Armington elasticities, suitable for use in further applied work such as AGE modelling with a GTAP model.

Using data that matches the level of aggregation contained in the GTAP dataset we obtain long-run estimates to match the timeframe of AGE models and our results demonstrate that the current GTAP Armington elasticities are too large in general. With elasticities in the range of 0.001 to 2.69, the results of this paper suggest that the GTAP parameters of Armington elasticities are too high for an economy such as the United Kingdom. Thus, leading us to conclude that the GTAP model, with its current parameters, may inflate the gains from trade resulting from trade liberalisation. Ensuring that the Armington elasticities used in AGE modelling are informed and contextualised by empirical analysis is essential to ensuring the reliability of policy analysis. Zhang (2006) demonstrates that size of the Armington elasticities can have a large effect of the terms of trade (the ratio of export to import prices) thus highlighting the importance of having reliable, model-consistent and empirically sound estimates for Armington elasticities in AGE models. Our work in this paper to perform the analysis needed to best capture the Armington elasticities for the UK economy is therefore essential to ensuring the value of analysis of trade measures in the UK.

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Annexes

Table 2: OLS, PAM and ECM elasticity estimates

		OLS (with Monthly Dummies)	PAM (with Monthly Dummies)	ECM		ECM with Optimal Spec		GTAP model
				Short-Run	Long-Run	Short-Run	Long-Run	
Paddy rice (pdr)	**Elasticity**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**5.05**
	Significance							
	SE							
	t-stat							
	R2							
Wheat (wht)	**Elasticity**	**1.0776**	**1.1739**	**0.9393**	**1.0142**		**1.6898**	**4.45**
	Significance						***	
	SE	0.5697	0.5938	0.8385	0.8225		0.4643	
	t-stat	1.8900	1.9800	1.1200	1.2300		3.6400	
	R2	0.1399	0.2130	0.4832		0.6187		
Other Grains (gro)	**Elasticity**	**0.9024**	**0.9105**	**0.7102**	**0.7453**	**1.0486**	**-0.4656**	**1.30**
	Significance	***	***	**	*	**		
	SE	0.1386	0.1848	0.2099	0.3482	0.2757	0.7260	
	t-stat	6.5100	4.9300	3.3800	2.1400	3.8000	-0.6400	
	R2	0.6583	0.6037	0.8120		0.8794		
Vegetables & fruits (v_f)	**Elasticity**	**0.7077**	**0.2302**	**0.3981**	**-2.8799**	**0.5279**	**0.1267**	**1.85**
	Significance			*				
	SE	0.4949	0.2542	0.1814	7.4199	0.2736	3.0753	
	t-stat	1.4300	0.9100	2.1900	-0.3900	1.9300	0.0400	
	R2	0.0850	0.8658	0.2692		0.4415		
Oil Seeds (osd)	**Elasticity**	**1.2868**	**0.4932**	**0.1463**	**1.5831**		**1.2284**	**2.45**
	Significance	*						
	SE	0.5236	0.3487	0.3583	1.8915		1.2996	
	t-stat	2.4600	1.4100	0.4100	0.8400		0.9500	
	R2	0.2154	0.7224	0.2162		0.2665		
Cane & Beets sugar crops (c_b)	**Elasticity**	**0.6026**	**0.6183**	**0.8496**	**-0.3681**	**0.9438**	**-0.2827**	**2.70**
	Significance	*	*	***		***		
	SE	0.2286	0.2221	0.1473	0.8980	0.1647	0.7767	
	t-stat	2.6400	2.7800	5.7700	-0.4100	5.7300	-0.3600	
	R2	0.2401	0.4474	0.8034		0.9007		
Plant based fiber (pbf)	**Elasticity**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**2.50**
	Significance							
	SE							

	t-stat							
	R2							
Other crops (ocr)	**Elasticity**	**1.0472**	**0.5633**	**0.0550**	**0.9204**		**0.8795**	**3.25**
	Significance	***	*		**			
	SE	0.1580	0.2154	0.2624	0.3125		0.4511	
	t-stat	6.6300	2.6200	0.2100	2.9500		1.9500	
	R2	0.6665	0.7089	0.3967		0.3571		
Cattle (ctl)	**Elasticity**	**0.9199**	**0.8932**	**0.8084**	**1.2256**	**0.8144**	**1.1092**	**2.00**
	Significance	***	***	***	***	***	**	
	SE	0.0345	0.0516	0.1092	0.2872	0.1154	0.3005	
	t-stat	26.6700	17.3000	7.4100	4.2700	7.0600	3.6900	
	R2	0.9700	0.9713	0.9871		0.9900		
Other Animal Products (oap)	**Elasticity**	**1.0771**	**1.0801**	**0.4456**	**1.1078**		**1.2102**	**1.30**
	Significance	***	***		***		***	
	SE	0.0325	0.0323	0.2264	0.0781		0.0567	
	t-stat	33.1300	33.4200	1.9700	14.1800		21.3500	
	R2	0.9804	0.9824	0.9924		0.9948		
Raw Milk (rmk)	**Elasticity**	**1.4177**	**0.6634**	**0.2981**	**1.1180**		**1.6170**	**3.65**
	Significance	*						
	SE	0.6147	0.5836	0.6146	2.1788		1.6150	
	t-stat	2.3100	1.1400	0.4900	0.5100		1.0000	
	R2	0.1947	0.4675	0.1609		0.1244		
Wool products (wol)	**Elasticity**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**6.45**
	Significance							
	SE							
	t-stat							
	R2							
Forestry (frs)	**Elasticity**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**2.50**
	Significance							
	SE							
	t-stat							
	R2							
Fishing products (fsh)	**Elasticity**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**1.25**
	Significance							
	SE							
	t-stat							
	R2							
Coal (coa)	**Elasticity**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**3.05**
	Significance							
	SE							
	t-stat							

	R2							
Oil products (oil)	**Elasticity**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**5.20**
	Significance							
	SE							
	t-stat							
	R2							
Gas products (gas)	**Elasticity**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**17.20**
	Significance							
	SE							
	t-stat							
	R2							
Other minerals (oxt)	**Elasticity**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**0.90**
	Significance							
	SE							
	t-stat							
	R2							
Cattle & Other meat (cmt & omt)	**Elasticity**	**0.3183**	**0.0339**	**0.3897**	**0.0010**		**-0.1154**	**3.85 & 4.40**
	Significance	**		*				
	SE	0.1051	0.1003	0.1592	0.1663		0.3025	
	t-stat	3.0300	0.3400	2.4500	0.0100		-0.3800	
	R2	0.3663	0.4434	0.7045		0.6928		
Vegetable oil (vol)	**Elasticity**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**3.30**
	Significance							
	SE							
	t-stat							
	R2							
Dairy products (mil)	**Elasticity**	**0.2130**	**-0.0362**	**0.6605**	**-0.2155**	**0.5564**	**-0.1855**	**3.65**
	Significance			**		*		
	SE	0.1411	0.1138	0.1930	0.2921	0.2617	0.4428	
	t-stat	1.5100	-0.3200	3.4200	-0.7400	2.1300	-0.4200	
	R2	0.4102	0.6724	0.6459		0.6433		
Processed rice (pcr)	**Elasticity**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**2.60**
	Significance							
	SE							
	t-stat							
	R2							
Sugar (sgr)	**Elasticity**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**2.70**
	Significance							

	SE t-stat R2							
Other food products (ofd)	**Elasticity**	**0.7856**	**0.1914**	**0.7896**	**-0.0523**	**0.8636**	**0.0023**	**2.00**
	Significance	***		***		***		
	SE	0.0713	0.1025	0.1346	0.3159	0.2051	0.1521	
	t-stat	11.0100	1.8700	5.8700	-0.1700	4.2100	0.0200	
	R2	0.8490	0.5826	0.9776		0.9563		
Beverage & tobacco (b_t)	**Elasticity**	**0.9360**	**0.6418**	**0.0780**	**0.9704**		**0.9849**	**1.15**
	Significance	***	***		***		***	
	SE	0.0365	0.0669	0.1519	0.0532		0.0539	
	t-stat	25.6700	9.6000	0.5100	18.2500		18.2800	
	R2	0.9188	0.9404	0.8547		0.8746		
Textiles (tex)	**Elasticity**	**0.8574**	**0.8614**	**0.9294**	**0.6323**	**0.9593**	**0.5594**	**3.75**
	Significance	***	***	***	***	***		
	SE	0.0288	0.0287	0.0229	0.1763	0.0217	0.3709	
	t-stat	29.7900	29.9900	40.5500	3.5900	44.2000	1.5100	
	R2	0.8166	0.8199	0.9897		0.9920		
Wearing Apparels (wap)	**Elasticity**	**-1.0748**	**0.1542**	**0.7986**	**0.0888**	**0.7141**	**2.6918**	**3.70**
	Significance	**		***		***		
	SE	0.3962	0.0760	0.1148	3.9889	0.1143	4.8255	
	t-stat	-2.7100	2.0300	6.9500	0.0200	6.2500	0.5600	
	R2	0.0533	0.9665	0.5146		0.5619		
Leather Products (lea)	**Elasticity**	**0.6409**	**0.6755**	**0.9430**	**0.7831**	**0.9316**	**0.7982**	**4.05**
	Significance	***	***	***		***		
	SE	0.1116	0.0723	0.0466	0.6209	0.0473	0.5416	
	t-stat	5.7400	9.3400	20.2500	1.2600	19.7100	1.4700	
	R2	0.1975	0.6618	0.8522		0.8552		
Lumber (lum)	**Elasticity**	**1.2984**	**0.4942**	**0.7761**	**1.4124**	**0.8141**	**1.6854**	**3.40**
	Significance	***	***	***	***	***	**	
	SE	0.1270	0.1024	0.1831	0.3764	0.1786	0.5095	
	t-stat	10.2300	4.8300	4.2400	3.7500	4.5600	3.3100	
	R2	0.4316	0.7444	0.4905		0.5337		
Paper & Paper Products (ppp)	**Elasticity**	**0.9641**	**0.9704**	**0.9192**	**0.9269**	**0.9437**	**0.9119**	**2.95**
	Significance	***	***	***	***	***	***	
	SE	0.0078	0.0081	0.0279	0.0401	0.0265	0.0589	
	t-stat	124.0200	120.2600	32.9600	23.1200	35.6000	15.4900	
	R2	0.9900	0.9905	0.9991		0.9993		
petroleum products (p_c)	**Elasticity**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**2.10**

	Significance							
	SE							
	t-stat							
	R2							
chemical Products (chm)	**Elasticity**	**0.8740**	**0.8509**	**0.9227**	**0.4129**	**0.9574**	**-0.0960**	**3.30**
	Significance	***	***	***		***		
	SE	0.0446	0.0421	0.0279	0.3514	0.0290	0.6626	
	t-stat	19.5900	20.1900	33.0900	1.1700	33.0300	-0.1400	
	R2	0.7112	0.7521	0.9769		0.9796		
Basic Pharmaceuticals Products (bph)	**Elasticity**	**0.1118**	**0.2484**	**0.8404**	**-0.1067**	**0.8813**	**-0.7122**	**3.30**
	Significance		***	***		***		
	SE	0.0739	0.0563	0.0393	0.3899	0.0412	1.5688	
	t-stat	1.5100	4.4100	21.3800	-0.2700	21.3900	-0.4500	
	R2	0.0701	0.4929	0.8423		0.8786		
Rubber & Plastic Products (rpp)	**Elasticity**	**-0.5021**	**0.0173**	**0.9969**	**-0.3173**	**1.0065**	**0.0713**	**3.30**
	Significance	***		***		***		
	SE	0.0674	0.0590	0.0637	0.3154	0.0716	0.8550	
	t-stat	-7.4500	0.2900	15.6500	-1.0100	14.0500	0.0800	
	R2	0.3043	0.6820	0.7285		0.7643		
Non Metallic Mineral products (nmm)	**Elasticity**	**0.9150**	**0.8719**	**0.9506**	**1.0741**	**0.9932**	**0.6213**	**2.90**
	Significance	***	***	***		***		
	SE	0.0788	0.0602	0.0362	0.5651	0.0473	1.2896	
	t-stat	11.6100	14.4800	26.2600	1.9000	21.0000	0.4800	
	R2	0.4973	0.7137	0.9444		0.9545		
iron & steel (i_s)	**Elasticity**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**2.95**
	Significance							
	SE							
	t-stat							
	R2							
non ferrous metals (nfm)	**Elasticity**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**4.20**
	Significance							
	SE							
	t-stat							
	R2							
fabricated metal products (fmp)	**Elasticity**	**0.6736**	**0.5789**	**0.8235**	**0.5580**	**0.8997**	**0.4422**	**3.75**
	Significance	***	***	***	***	***		

	SE	0.0401	0.0430	0.0452	0.1229	0.0477	0.2244	
	t-stat	16.8100	13.4500	18.2100	4.5400	18.8700	1.9700	
	R2	0.6605	0.7045	0.8972		0.9081		
electronic products (ele)	**Elasticity**	**0.5901**	**0.5667**	**0.9166**	**0.5973**	**0.9402**	**0.5859**	**4.40**
	Significance	***	***	***	***	***	***	
	SE	0.0205	0.0294	0.0360	0.0813	0.0360	0.0901	
	t-stat	28.7600	19.2600	25.4800	7.3500	26.0800	6.5000	
	R2	0.8422	0.8440	0.9556		0.9598		
electrical equipment (eeq)	**Elasticity**	**-0.5991**	**0.1455**	**0.7958**	**-1.5243**	**0.7842**	**-1.9336**	**4.05**
	Significance	***		***		***		
	SE	0.1598	0.0947	0.0597	1.0557	0.0899	2.6203	
	t-stat	-3.7500	1.5400	13.3300	-1.4400	8.7200	-0.7400	
	R2	0.1431	0.8383	0.7354		0.7508		
machinery & equipment (ome)	**Elasticity**	**0.9949**	**0.9890**	**0.7626**	**1.0394**	**0.8730**	**1.1146**	**4.05**
	Significance	***	***	***	***	***	***	
	SE	0.0161	0.0163	0.0506	0.0587	0.0545	0.1542	
	t-stat	61.8300	60.7500	15.0800	17.7100	16.0100	7.2300	
	R2	0.9605	0.9619	0.9895		0.9911		
Motor Vehicles (mvh)	**Elasticity**	**-0.2171**	**-0.1166**	**1.1705**	**-0.2656**	**1.2735**	**-0.3852**	**3.75**
	Significance	***		***	**	***		
	SE	0.0591	0.0612	0.1562	0.0922	0.1560	0.1668	
	t-stat	-3.6700	-1.9000	7.4900	-2.8800	8.1700	-2.3100	
	R2	0.3189	0.3780	0.6650		0.7701		
Other Transport Equipment (otn)	**Elasticity**	**0.9854**	**0.9838**	**0.4809**	**1.0136**	**0.4668**	**1.0118**	**3.75**
	Significance	***	***	***	***	***	***	
	SE	0.0109	0.0108	0.0672	0.0264	0.0679	0.0255	
	t-stat	90.6500	90.9200	7.1500	38.4200	6.8800	39.6100	
	R2	0.9814	0.9819	0.9924		0.9926		
Other manufacturing (omf)	**Elasticity**	**0.0995**	**0.3384**	**0.7305**	**0.2910**	**0.7501**	**0.3165**	**3.75**
	Significance		***	***		***		
	SE	0.0839	0.0609	0.0404	0.5642	0.0466	0.9581	
	t-stat	1.1900	5.5600	18.1000	0.5200	16.0900	0.3300	
	R2	0.1414	0.5902	0.8200		0.8663		