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**Article**

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# **The Impact of World War Two and Rationing on U.K. Expenditure in the Short and Long Run**

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## **ABSTRACT**

World War Two, rationing, and shortages limited the amount of food and other goods available to households. The new welfare state of Clement Attlee's Labour Party and derationing were supposed to provide food and other consumption goods to meet the needs of households, but voters were dissatisfied. Churchill's Conservative Party, with a campaign promising to end rationing quickly, regained power. It is unclear how rationing affected households' expenditure adjustments in the short and long run. Our results show that income and own-price elasticities varied considerably in both the short and long run before, during and after the war. Varying elasticities provide insight into how households adjusted their expenditures over time. Food is typically an essential consumption item, but estimates show it was almost a luxury good during the war and in the postwar period. There is evidence that households were unable to make typical long-run desired expenditure adjustments during the war and for some time after it. Binding food rationing significantly affected spending on other goods and services. Rationing had a severe impact on household expenditures. The campaign to end rationing was pivotal in the Conservatives Party's landslide victory.

## **1. Introduction**

For Great Britain, the postwar period was a time of economic upheaval and fierce political and economic debate that ushered in

major changes in economic policy. Progressive policy changes emerged as an inevitable outcome of the economic sacrifices that the population had borne for the war effort. Britain had always been highly dependent on imports of certain goods, notably many food items. Just one month after World War Two began, Britain experienced a massive decline in imports of food and other products.<sup>1</sup> Having barely recovered from the Great Depression, Britons once again faced food shortages, fluctuating prices, and a limited supply of specific goods. To address these challenges, the government established a rationing system on 8 January 1940. Private consumption was heavily regulated and austerity led to a change in consumption patterns.<sup>2</sup>

Long before the end of the war was in sight, policymakers and experts wrestled with how to rebuild the economy after the war, proposing policy changes to ensure economic growth, stable prices and domestic prosperity. The future of postwar Britain was largely influenced by liberal economists like John Maynard Keynes and William Beveridge as well as by the left-wing politician Aneurin Bevan, all of whom advocated for government intervention.<sup>3</sup> Keynes, concerned about wartime inflation, called for an increase in taxes, with compulsory savings, to pay for the war.<sup>4</sup> He predicted that inflation would rise as output and income increased. Beveridge had worked extensively on issues regarding unemployment and social security. In 1941, the government commissioned him to write a report on how to rebuild Britain after the war. The Beveridge Report

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<sup>1</sup> Imports accounted for 70% of prewar food consumption; Murray (1955). Imports of sugar, wheat and other products fell substantially; Central Statistical Office, *Statistical Digest of the War*.

<sup>2</sup> The impact of austerity in Britain on private consumption and the political outcomes are discussed in detail by Zweiniger-Bargielowska (1994, 2000).

<sup>3</sup> For details of their respective contributions and the implementation of many of their ideas, see, among others, Harris (1977), Moggridge (1992), Skidelsky (2000) and Barr (2004).

<sup>4</sup> Keynes (1940) set out his ideas in articles collected in the pamphlet *How to Pay for the War*.

(Beveridge, 1942) proposed a welfare state.<sup>5</sup> It argued that welfare institutions would make postwar British industry more competitive because major components of labor costs, such as pensions and healthcare, would be covered by the public finances. The social welfare program aimed at attaining full employment, defined as unemployment not exceeding 3%. Bevan, one of the foremost politicians pushing for the creation of a welfare state, urged the government to undertake radical changes. He called for the nationalization of the coal industry and hospitals, and is regarded as the chief architect of the National Health Service.

War-weary and wanting an end to wartime austerity, the population was ready for new leadership and voted for it in the 1945 general election, giving Clement Attlee's Labour Party victory over Winston Churchill's Conservatives. The Attlee government began to implement the welfare state outlined in the 1942 Beveridge Report.<sup>6</sup> The transition from a wartime economy to a peacetime free market posed many questions about how best to lift rationing at a time when Britons still faced food and goods shortages. It was important to determine the impact that derationing would have on the demand for unrationed goods that were either substitutes or complements in consumption, in order to prevent shortages.<sup>7</sup> Ending rationing would increase the demand for goods that were complements and not subject to rationing, but the substitution and income effects would determine the impact on unrationed goods that were substitutes.<sup>8</sup> Derationing of some goods began

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<sup>5</sup> Churchill's Conservatives had a four-year plan for postwar reconstruction and generally opposed much of the Beveridge Report. They also voted against the creation of the National Health Service (Jefferys, 1994).

<sup>6</sup> Taxes were increased and the coal, steel, iron, gas and electricity industries, along with the railways, were nationalized.

<sup>7</sup> The work of Stone (1945, 1954), Tobin and Houthakker (1951), Stone and Rowe (1954, 1966) and Houthakker and Tobin (1952) gave policymakers valuable input on rationing (Johansen, 1985; Pesaran and Harcourt, 2000).

<sup>8</sup> This was rather complicated to calculate because of rationing. It was necessary to figure out the virtual price and how to estimate a free demand system (Tobin and Houthakker, 1951; Pollak, 1969), Neary and Roberts, 1980; Mackay and Whitney, 1980; Deaton, 1981).

in 1948.<sup>9</sup> Voters were dissatisfied with the overall outcome of the new policies and complained that rationing was still stifling consumption. When to end rationing was a major issue of the 1950 general election. The Conservatives wanted to end it quickly, while Labour argued that rationing remained essential to stabilizing the economy. The Conservatives made gains, and then, in the 1951 election, defeated Labour and proceeded with derationing of food and goods. The last vestiges of wartime rationing of food products disappeared with the ending of rationing of meat and bacon in July 1954, almost a decade after the end of the war.

Economists have provided estimates of how rationing affected consumer expenditure during the war and postwar period.<sup>10</sup> A limitation of these studies is that the income and own-price elasticities of demand are constrained to remain constant over the entire period. There is no reason to assume that elasticities will remain constant, especially under a regime of rationing and shortages. Furthermore, there are no studies comparing the impact that rationing and derationing had on consumer choices in both the short and long term. This is rather surprising, given the transition from a rationed to a free market system and the construction of a new welfare state that significantly impacted consumer expenditure.

The present study uses the semi-nonparametric Fourier flexible form to estimate a “free” demand system and extends the work of Tobin and Houthakker (1951), Houthakker and Tobin (1952), Bettendorf and Buyst (1997), and Fleissig and Whitney (2014). I do not constrain the short and long-run estimates of income and own-price elasticities to be constant over the sample. The short-run estimates typically should differ from the long-run estimates since households have more time to make expenditure adjustments. Thus the impact that rationing, the new welfare state, and derationing had on potential changes in short and long-run elasticities is estimated over time

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<sup>9</sup> Bread was not rationed during the war, but it was rationed in July 1946.

<sup>10</sup> See Tobin and Houthakker (1951), Houthakker and Tobin (1952), Stone (1954), Tobin and Houthakker (1951), and Deaton (1981).

from World War Two through 1955, the first year without food rationing.<sup>11</sup> Given the shortages and rationing, it may well be that the short and long-run estimates of substitution for food and goods converge over certain periods, in particular during the war. I also estimate how binding food rationing, which reduces food expenditure, affected expenditure on other goods. Rationing, the new welfare state, and derationing had some unexpected impacts on the short and long-run estimates of income and own-price elasticities.

## 2. Rationing and Virtual Prices

The introduction of rationing of certain goods was deemed necessary during the war to stabilize prices and provide a more equitable distribution of food items and goods. This required obtaining information about the structure of each household, which necessitated the unpopular National Registration Day of 29 September 1939. Some of the population welcomed rationing in the belief that it would curb price mark-ups by retailers and potentially provide some assurance that they would be able to purchase their allotted amounts of food and goods. However, public protests delayed the inception of rationing, which was only introduced on 8 January 1940 by the Ministry of Food. The first foods to be rationed were bacon, butter, and sugar. Rationing was soon imposed on all meat, jam, fish, biscuits, tea, dairy products, and many other items. Rationing of sweets and chocolate began in 1942. Turning to non-food items, petrol had been rationed since 1939. Rationing of clothing began in 1941. By 1948, some products were no longer rationed, but it took another five years before rationing was lifted for all products. Clothes rationing ended in 1949 and petrol rationing in 1950. All food products were no longer subject to rationing by 1954.

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<sup>11</sup> Previous studies either provide estimates at the mean of the data or do not distinguish between the short and long term (Tobin and Houthakker, 1951; Houthakker and Tobin, 1952; Deaton, 1981; Fleissig and Whitney, 2014).

In the presence of binding rationing of a particular good, the price of the rationed good is the virtual price, as in Rothbarth (1941) and Neary and Roberts (1980). By replacing the actual price with the virtual price, a “free” demand system can be estimated.<sup>12</sup> In estimating such a system, elasticities of demand and the impact that a rationed good had on unrationed goods can be examined (Neary and Roberts, 1980; Mackay and Whitney, 1980). A number of methods have been used to replace the actual price with a virtual price. Actual prices from the unconstrained markets of Germany have been used as a proxy for the virtual price during the rationed or pre-reform period of 1987 through 1989 in Poland (Huffman and Johnson, 2004). Another approach, used by Bettendorf and Buyst (1997) and Huffman and Johnson (2004), is to follow the methodology of Hausman (1997) and estimate virtual prices from a demand system over a post-rationed period. Neither of these approaches uses observed data from the period of rationing to calculate virtual prices.

An alternative is to derive the virtual prices of goods that are consistent with consumer choices under rationing using the non-parametric revealed preference approach, developed by Varian (1983) and extended to multiple goods by Fleissig and Whitney (2011). The advantages of this method is that it uses the actual data during the rationed and unrationed periods, does not require specifying a utility functional form, and is frequently applied to data to evaluate consumer demand. In applications where rationing may be present, it is not necessarily clear if rationing of a particular good is binding or not. The linear programming procedure of Fleissig and Whitney (2011), which enhances the approaches of Diewert (1973) and Varian (1983), is used to test for binding rationing (see Appendix 1).

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<sup>12</sup> A free demand system for the linear expenditure system is discussed by Neary and Roberts (1980). Virtual prices are used by Huffman and Johnson (2004) over a period of rationing in Poland, by Bettendorf and Buyst (1997) and Fleissig and Whitney (2013) for rent control in Belgium, and by Fleissig and Whitney (2014) for rationing in Britain.

### 3. Data and Dynamic Fourier Flexible Form

The annual data cover the period 1920 through 1955 in the United Kingdom for England, Wales, Scotland, and Northern Ireland, (Stone and Rowe, 1954, 1966). There are ten categories of goods and services: food; alcoholic beverages; tobacco; rents; fuel and electricity; clothing; durable household goods; transportation and communications; other goods; and other services. Other services consist of domestic service, entertainment, insurance and other miscellaneous services. Other goods include household goods, books, fancy goods, toys, sporting goods, drugs and medical appliances. The price index for each category is obtained by dividing current expenditures by constant expenditures, and constant expenditures are converted into per capita terms using the adult equivalent population. This data set is used to estimate virtual prices during wartime rationing. Fleissig and Whitney (2011) apply the linear programming rationing procedure to the data and find evidence of binding rationing on food in 1947 and for other services in 1952. They calculate the corresponding virtual prices. These virtual prices can then be used instead of the actual prices during the wartime rationing period to estimate a “free” demand system of equations.

The Rotterdam model has been used to estimate a system of “free” demand equations (Bettendorf and Buyst, 1997; Fleissig and Whitney, 2014). These studies provide own-price and income elasticity estimates at the mean of the data but fail to allow substitution estimates to vary over time and do not distinguish between the short and the long run. However, because the Rotterdam model is a locally flexible functional form, it is not dense in a Sobolev norm and can only provide a local approximation to the data generating function and elasticity estimates in a delta neighborhood of a typically small size (Gallant, 1981).

By contrast, the semi-nonparametric globally flexible Fourier functional form is dense in a Sobolev norm and can globally approximate the levels and partial derivatives of a continuous utility function (Gallant, 1981). The Fourier flexible form can provide elasticity



estimates at each data point, (Elbadawi, Gallant, and Souza, 1983). It has been used in earlier studies by Ewis and Fisher (1985), Mitchell and Onvural (1996), and others, and discussed in the reviews of demand systems by Barnett, Fisher, and Serletis (1992) and Fisher, Fleissig, and Serletis (2001).

Fewer goods can typically be estimated when using the Fourier flexible form, so it is necessary to construct some aggregates. The Divisia Index is used to construct aggregates because of its aggregator properties and ability to better internalize substitution effects (Barnett, 1980; Jorgenson and Griliches, 1967; Diewert, 1993). The six categories are food, other services, rents, Divisia aggregate of fuel and transportation, Divisia aggregate of alcohol and tobacco, and Divisia aggregate of clothing, durable household goods, and other goods. Since it may have taken consumers up to three years to adjust expenditure over the end of rationing, the dynamic Fourier flexible form is used, allowing for three years of adjustment (Fisher and Fleissig, 1994; Appendix 2).

#### **4. Income Elasticities of Demand**

Income elasticities of demand tend to differ in the short run compared with the long run and specifically depend on whether the good is a luxury or a necessity in consumption as well as on the amount of time people have to adjust expenditure. Typically, for most goods and services, such as fuel, food, beverages, and entertainment, the income elasticity of demand is generally much greater in the long run than in the short run. For these goods and services, consumers will eventually adjust expenditure so that income elasticities of demand are typically larger in the long run. By contrast, for goods classified as luxuries, which are often durable goods, the income elasticity of demand is expected to be higher in the short run compared with the long run. For example, as income increases, consumers purchase more durable goods, such as automobiles, which tend to last for a number of years so that the short-run income elas-

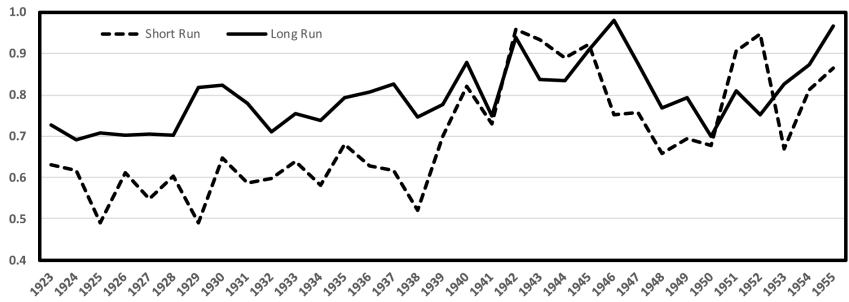
ticity of demand is likely to be higher than the long-run estimates. The empirical issue is to estimate how the war, rationing, and the postwar period impacted the income elasticities of demand in both the short and the long run. The estimated income elasticities are all statistically significantly different from zero and positive (Appendix 3a). The results are extensive. Some key findings are now discussed.

Food rationing, shortages, and fluctuating prices had a significant impact on expenditure over time. The overall category of food is generally classified as a necessity, and the income elasticity estimates are expected to be relatively small. This is not always the case over the sample for both the short and long run, with the income elasticities of food displayed in Figure 1a. The short-run income elasticities range from 0.489 to 0.958, having an average of 0.702. In the long run, the income elasticities range from 0.690 to 0.980 with an average of 0.797.

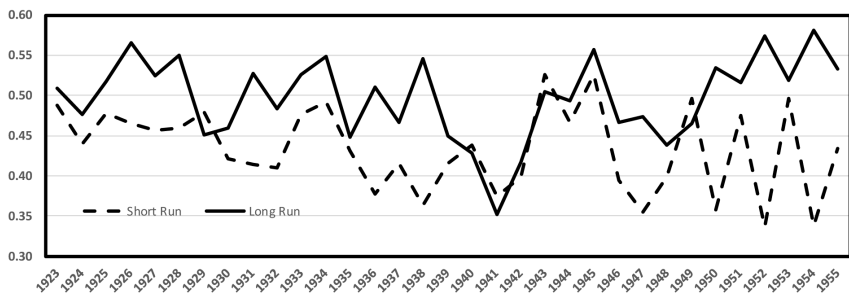
On average, the short and long-run income elasticities for food are relatively high for goods typically classified as necessities and show rationing's detrimental impact on consumers. Food should be considered a necessity, not a luxury. The estimates vary substantially over the sample. Using the Rotterdam model, the estimate of the food income elasticity of demand from Fleissig and Whitney (2014) at the mean of the data was 0.743, which is in between the short and long-run averages.

Public protests over shortages of certain food products were common before the imposition of rationing. Prior to the introduction of rationing of food items beginning in 1940, the income elasticity of demand for food was larger in the long run than in the short run, which is consistent with economic theory. At the start of World War Two, the short and long-run income elasticities of demand were on an upward trend, becoming more elastic, and converged as food rationing impacted consumers. Contrary to prevailing economic theory, the short-run income elasticity of demand actually exceeded the long-run elasticity for some periods during the war, suggesting that consumers were unable to make expenditure adjustments, which typically occur in the long run. It may also be that, because of short-

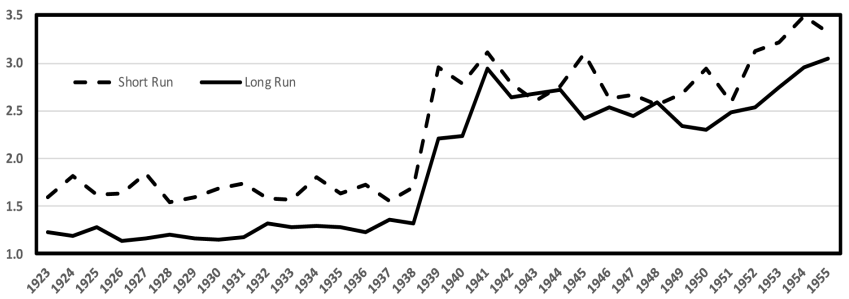
**FIGURE 1a**  
Income Elasticity of Demand for Food



**FIGURE 1b**  
Income Elasticity of Demand for Alcoholic Beverages and Tobacco



**FIGURE 1c**  
Income Elasticity of Demand for Clothing, Durable Household Goods, and Other Goods



ages and rationing, certain types of food were considered near-luxuries in consumption.

Rationing of some food and non-food goods ended in 1948, with the last food items derationed in 1954. Once food rationing began to be eliminated, the long-run elasticities began to exceed the short-run estimates, as the income elasticity of food declined. After the war, there is evidence of more rapid short-term adjustment, with the short-run estimates exceeding long-run estimates for 1951 and 1952. For the remainder of the sample, there was a surge in both the short and long-run income elasticities for food, which became more income elastic, and, once again, the long-run elasticities exceeded the short-run estimates.

Alcohol and cigarettes were not officially rationed but there were shortages. The short-run estimates range from 0.336 to 0.526, with an average of 0.433, and also show considerable variability over the sample (Figure 1b; Appendix 3a). For the long run, the estimates are slightly higher, ranging from 0.352 to 0.581, with an average of 0.497. The estimates from the Rotterdam model at the mean of the data were 0.412 for alcohol and 0.266 for tobacco (Fleissig and Whitney, 2014). In the prewar period, the long-run income elasticities for alcoholic beverages and tobacco generally exceed the short-run estimates. During the war years, as income typically declined, both the estimated short and long-run income elasticities of demand decreased, as these goods were often in short supply. As with the estimates for food, the short and long-run income elasticities of demand for these goods converge, suggesting little adjustment by consumers in the long run. After the war, alcohol and tobacco were more readily available and, with consumers generally having higher incomes, the short-run income elasticity became considerably more variable compared with the long-run estimates. From 1950 onwards, the income elasticity of demand was once again greater in the long-run compared with the short-run estimates.

During the Great Depression and the war, items such as clothing, durable household goods, and other goods were often considered luxuries. This is confirmed by the estimates (Figure 1c). The short-

run income elasticities range from 1.546 to 3.486 with an average of 2.302 whereas the long-run estimates range from 1.137 to 3.049 with an average of 1.925. The estimates from the Rotterdam model at the mean of the data were 2.182 (clothing), 2.831 (durable household goods) and 0.801 (other goods).

A number of interesting trends appear over the sample. The difference between the minimum and maximum estimated income elasticities of demand in both the short and long-run was larger for clothing, durable household goods, and other goods than for the remaining goods and services examined. The short-run income elasticities of the demand for clothing, durable household goods, and other goods generally exceeded the long-run estimates, as expected, because people tend to purchase these goods in lump sum expenditures and wait a number of years before replacing them. Both the short and long-run estimates are relatively less variable in the prewar period. During the war, the estimates for both the short-run and the long run (from 2.606 to 3.117 and from 2.207 to 2.946, respectively) trend upwards and increase considerably. These items were typically in short supply during the war and demand became increasingly more income elastic. Postwar estimates, when more products were available, become less variable before resuming the upward trend in 1951.

In summary, the short and long-run income elasticity estimates often differ significantly and show considerable variation over the sample. While economic theory suggests that the short and long-run estimates should differ as households have more time to make adjustments, there are periods during the war and postwar years when the short and long-run estimates converge due to rationing and shortages of goods and services. For most goods and services, the short and long-run income elasticities of demand are similar in the prewar and postwar periods. Exceptions are clothing, durable household goods, and other goods, which become increasingly elastic, perhaps because more of these goods reappeared on the market.

## 5. Own-Price Elasticity of Demand

The own-price elasticity of demand for necessities, such as food, is typically inelastic. Shortages, rationing, and fluctuating prices are bound to impact short and long-term consumer purchases. All of the estimated own-price elasticities of demand are statistically significantly different from zero and negative, which is consistent with the law of demand (Appendix 3b). Some key results are now discussed.

Evidence of binding food rationing was detected in 1947. For food, the short-run own-price elasticities are more inelastic compared with the long-run estimates prior to the war (Figure 2a). During the prewar period, the own-price elasticities are relatively inelastic and under -0.31. Own-price elasticities vary considerably over the sample, from -0.616 to -0.123 over the short run and from -0.561 to -0.196 for the long run. The own-price elasticity estimate from the Rotterdam model was -0.007. During the war, both the short and long-run estimates become significantly less inelastic, with the least inelastic values of -0.616 (year 1943) in the short run and -0.561 (year 1944) in the long run. The short and long-run own-price elasticities converge during the war, as the impact of shortages of various types of food limited the typical opportunities for consumers to make adjustments in the long run. Once the war ended, both the short and the long-run estimates become less inelastic, with values close to the prewar period.

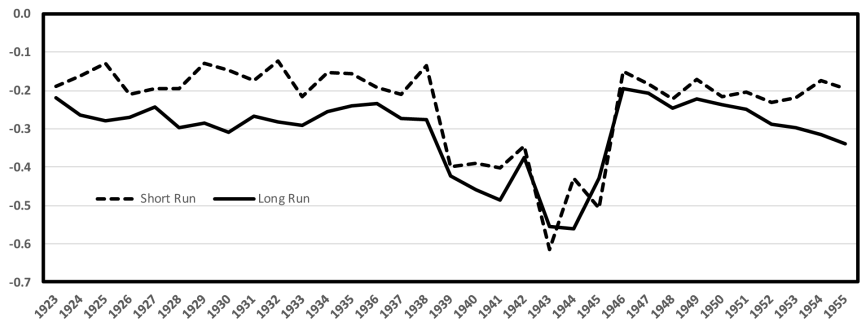
Evidence of binding rationing was detected in 1952 for other services. The own-price elasticities of demand for other services in the short and long run are highly inelastic and range from -0.282 to -0.015 (Figure 2b). The variability in the own-price elasticity estimates is pronounced by comparison with the estimate at the mean of the data of -0.071 for the Rotterdam model. Before the war, the long-run elasticity was smaller compared with the short-run estimates, which is typically the case as households become more flexible for other services in the long-run. Own-price elasticity estimates changed from being highly inelastic (greater than 0.110 and close to zero) to values smaller than -0.2 by 1927. Own-price elasticities of

demand for other services subsequently became more inelastic, but this trend reversed after the war began. As with all the estimates, there was a period during the war when the short and long-run estimates converged, reflecting limited ability for adjustment in the long run. By 1955, own-price elasticity was less inelastic in the long run, with values similar to those of 1923.

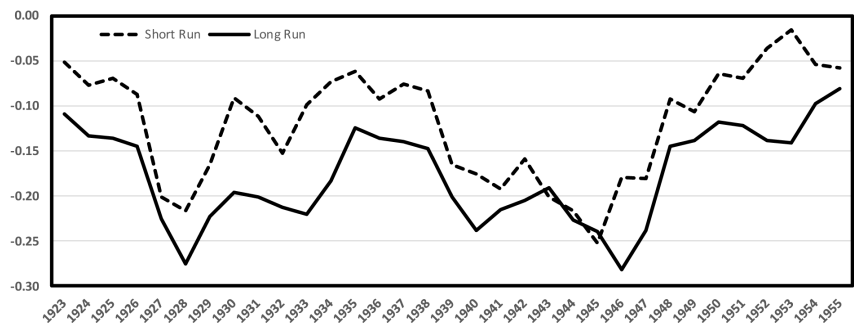
Petrol rationing began in 1939 and ended in 1950. Our main finding is the considerable variability in both the short and long-run estimates (Figure 2c). The short-run own-price elasticities range from -0.939 to -0.583, with an average of -0.713. In the long run, the estimates range from -0.969 to -0.705, with an average of -0.814. Prior to the war, the own-price elasticity of demand for fuel and transportation was less inelastic in the long run compared with the short run, which is typically the case for fuel and transportation. After rationing was imposed, the demand for fuel and transportation fell. Due to shortages of fuel and transportation, there was a period when the short-run own-price elasticities were less inelastic than the long-run estimates. The own-price elasticities of demand became increasingly less inelastic in the short run until 1941, when they reached a minimum value of -0.939. In the long run, the own-price elasticities also come close to being elastic, with a value of -0.969 in 1947. The short and long-run estimates converge in the years 1939, 1940, and 1942, suggesting an inability to make typical long-run adjustments. The frequent changes in the price of petrol is reflected in the considerable variability in the short-run own-price estimates, which generally become more inelastic after 1941. While the price of petrol continued to increase after the war, the long-run estimates are less inelastic compared with the short-run values.

Summing up, once again there are significant differences between the short and long-run own-price elasticity estimates and much variability over the sample. This variability in the own-price elasticity estimates and the difference between the short and long-run estimates cannot be detected using the Rotterdam model. There was a period of time during the war and postwar years when the short and long-run estimates converged, reflecting the inability of

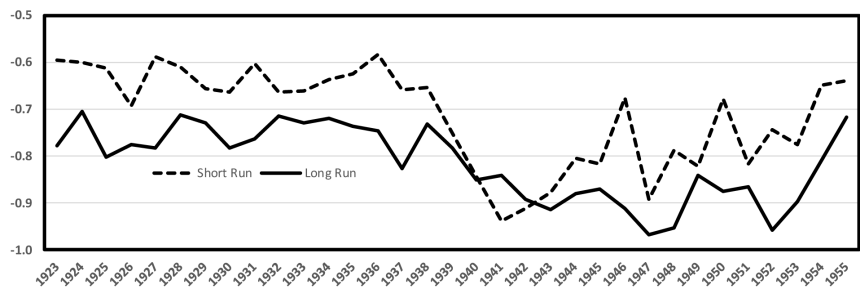
**FIGURE 2a**  
Own-Price Elasticity of Demand for Food



**FIGURE 2b**  
Own-Price Elasticity of Demand for Other Services



**FIGURE 2c**  
Own-Price Elasticity of Demand for Fuel and Transportation





consumers to make the typical desired expenditure adjustments in the long-run. All of the goods and services are inelastic in demand except for the Divisia aggregate for clothing, durable household goods, and other goods, which are elastic over parts of the sample. While the short and long-run estimates tend to be similar in the pre-war and postwar periods, this is still not the case for the Divisia aggregate of clothing, durable household goods, and other goods, which actually becomes more elastic after the war.

## 6. Impact of Food Rationing on Expenditure for Goods and Services

To analyze the impact that binding food rationing in 1947 had on expenditure for other goods and services, equation (2) (Fleissig and Whitney, 2013) and the estimates from the Fourier flexible form are used. Binding food rationing's impact on expenditure on the remaining goods and services was substantial (Table 1). Increasing rationing on food by one per cent decreased expenditure on fuel and transportation significantly, with declines of 5.842% in the short run and 4.293% in the long run. The impact of binding food rationing decreased expenditure on clothing, durable household goods, and other goods by as much as 7.365% in the short run and 5.648% in the long run. Results show that binding food rationing had a smaller, but still considerable, impact on spending on alcoholic beverages and tobacco, decreasing it by 2.457% in the short run and 3.432% in the long run.

Binding food rationing increased expenditure on other services (2.635% in short run and 3.163% in long run) and rents (5.234% in short run and 6.367% in long-run). The impact of binding food rationing was smaller in the short run than in the long run for alcoholic beverages and tobacco, other services, and rents. By contrast, its impact was greater in the long run for fuel and transportation as well as for clothing and durable household goods.

**TABLE 1**  
Impact of Binding Food Rationing in 1947

Elasticity	Fuel and Transportation	Clothing, Durable Household Goods, Other Goods	Alcoholic Beverages and Tobacco	Other Services	Rents
Short-run	-5.842	-7.365	-2.457	2.635	5.234
Long-run	-4.293	-5.648	-3.432	3.163	6.367

## 7. Conclusions

Wartime shortages and rationing limited the availability of certain food items and goods, while after the war the new welfare state and derationing were supposed to provide a supply of food and goods to meet the needs of households. The welfare state instituted by the Labour Party and the start of derationing failed to stabilize the economy. Churchill's Conservative Party made ending rationing a central issue of the 1950 general election and went on to defeat Labour in the 1951 election and end rationing in 1954. Estimates of the income and own-price elasticities show considerable variability and also reveal that households were unable to make typical desired short and long-run expenditure adjustments. Our results show the severe impact that rationing had on household expenditures and provide further insight into the importance of the Conservative Party's campaign to quickly end rationing and its consequent landslide victory.

This research allows for differences in estimated short and long-run income and own-price elasticities over the sample instead of restricting them to be constant at all data points. Short and long-run own-price and income elasticities were estimated from a "free" demand system, using virtual prices because of binding food rationing. A main result is the evidence of considerable variability in both the short and long-run estimates of the income and own-price elasticities before, during, and after World War Two. This variability sheds light on how households' made expenditure adjustments over time.

While the trends in the income elasticity estimates for nondurable goods are similar in the prewar and postwar periods, this is not the case for food, clothing, and durable goods, which become more elastic during the postwar period. Estimated income elasticities for food during the war and the postwar period often increase, so that food, which was not readily available, came close to being classified as a luxury good. For Britons, it was essential that food be much more a necessity in consumption than a near-luxury good and this played a part in Labour's ouster from government. The short and long-run estimated income elasticities of demand for clothing, durable household goods, and other goods increase substantially after 1938; these items were luxuries over the entire sample. While no rationing was imposed on alcoholic beverages and tobacco, there is considerable variability in the estimated income elasticities of demand partly due to significant variations in the supply of these goods. For food, the own-price elasticities are relatively inelastic in the prewar and postwar periods but become much less inelastic during the war. The own-price elasticities for other services show considerable variability over the sample but in general they are relatively inelastic. Fuel and transportation own-price elasticities became much less inelastic during the war; after 1951, they begin to become more inelastic.

Another important result is that the short and long-run elasticity estimates typically converge during the war and also for some postwar periods, showing that households were unable to make typical desired expenditure adjustments over time. In the long run, households have more time to adjust purchases, and own-price and expenditure elasticities of demand should differ compared with the short run. Also, binding food rationing had a significant impact on expenditure for other goods and services in 1947 in both the short and long run. Increasing food rationing by one per cent would have substantially reduced expenditure on the aggregate of fuel and transportation, the aggregate of clothing, durable household goods, and other goods, and the aggregate of alcoholic beverages and tobacco, whereas expenditure on other services and rents would have increased.

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## Appendix 1

The following LP procedure is used to test for rationing,

$$\begin{aligned}
 \text{Min } Z &= \sum_{j=1}^n \sum_{g=1}^h w^g \mu^{gj} \\
 &\text{subject to} \\
 U^i &\leq U^j + \lambda^j p^j (x^i - x^j) + \mu^j A^j (x^i - x^j) \\
 \lambda^i &> 0 \\
 \mu^{gj} &\geq 0
 \end{aligned} \tag{1}$$

where  $w^g$  are the weights,  $\mu^{gj}$  are parameters to detect rationing,  $\mu^{gj} > 0$  for goods where rationing is binding,  $\mu^{gj} = 0$  in periods without binding rationing,  $U^i$ ,  $\lambda^i$  and  $\mu^{gj}$  are parameters that satisfy the Afriat (1967) inequalities under rationing, and  $p^i = (p_1^i, \dots, p_k^i)'$  and  $x^i = (x_1^i, \dots, x_k^i)'$  are price and quantity vectors. The aim is to find if there exists a feasible solution for the rationing inequalities that minimize the values of the rationing multipliers  $\mu^{gj}$ . If a feasible solution exists, then the data can be rationalized by a utility function for the entire

period in which rationing of some goods is present. This would indicate that there were no changes in preferences and that using pre-war data to estimate demand functions to predict postwar consumption patterns, as in Stone (1954), and to forecast the growth in demand during the war years, as in Houthakker and Tobin (1952), is supported by the data.

## Appendix 2

The dynamic Fourier flexible form of Fisher and Fleissig (1994) is used allowing for three years of adjustment,

$$f(z, \theta) = u_0 + b'z + \frac{1}{2}z'Cz + \sum_{\alpha=1}^A \left( u_{0\alpha} + 2 \sum_{j=1}^J \left[ u_{j\alpha} \cos(jk'_{\alpha}z) - w_{j\alpha} \sin(jk'_{\alpha}z) \right] \right) \quad (2)$$

where  $\theta = \{b, u_{0\alpha}, u_{j\alpha}, w_{j\alpha} : j = 1, 2, \dots, J; \alpha = 1, 2, \dots, A\}$  are parameters to be estimated,  $p_t = (p_{1t}, \dots, p_{6t})$  are prices and virtual prices,  $x_t = (x_{1t}, \dots, x_{6t})$  are real per capita quantities,  $v_t = p_t/y_t$  are expenditure normalized prices,  $y_t$  is total expenditure on the components, and  $z_t = (v_t, v_{t-1}, v_{t-2}, v_{t-3})$  captures the dynamic adjustment. A multi-index,  $k_{\alpha}$  denotes partial differentiation of the utility function and  $C = -\sum_{\alpha=1}^A u_{0\alpha} k_{\alpha} k'_{\alpha}$ ?. The dynamic Fourier share equations ( $s_i = p_{it}x_{it}/y_t$ ) are as follows:

$$s_i(z, \theta) = \frac{b_i z_i - \sum_{\alpha=1}^A \left( u_{0\alpha} z' k_{\alpha} + 2 \sum_{j=1}^J \left[ u_{j\alpha} \sin(jk'_{\alpha}z) + w_{j\alpha} \cos(jk'_{\alpha}z) \right] \right) k_{i\alpha} z_i}{b'z - \sum_{\alpha=1}^A \left( u_{0\alpha} z' k_{\alpha} + 2 \sum_{j=1}^J \left[ u_{j\alpha} \sin(jk'_{\alpha}z) + w_{j\alpha} \cos(jk'_{\alpha}z) \right] \right) k'_{\alpha} z} \quad (3)$$

and a normalization of  $b_6 = -1$  is imposed in estimation. Estimation is performed using International TSP 4.5 with convergence set at 0.00001. Multiple starting values and multi-indexes ( $k_{\alpha}$ ) were used to ensure convergence to the global optimum. The upward F-test procedure of Eastwood and Gallant (1991) is used to determine the degree of the Fourier polynomials ( $A = 4$  and  $J = 1$ ) allowing for three years of adjustment. The parameters are statistically significant and



estimates (see below). The income elasticities of demand and own-price elasticities of demand are estimated from the Fourier flexible form and parameter estimates.

Parameter Estimates for the Fourier Flexible Form

Parameter	Estimate	Standard Error	t-stat
b1	0.11583	0.01343	8.6240
b2	-0.05288	0.00666	-7.9439
b3	0.00251	0.00161	1.5577
b4	0.00125	0.00063	1.9843
b5	0.13616	0.01963	6.9359
u01	-0.11970	0.02979	-4.0186
u11	-0.07333	0.01650	-4.4453
w11	-0.13915	0.03556	-3.9136
u02	0.00297	0.00060	4.9062
u12	-0.00345	0.00293	-1.1757
w12	-0.03426	0.00463	-7.4007
u03	0.00175	0.00022	8.0856
u13	0.00011	0.00004	2.7513
w13	0.00024	0.00009	2.8204
u04	-0.00022	0.00003	-8.1147
u14	0.00105	0.00015	6.9214

- Estimation of the dynamic Fourier flexible form is performed in International TSP 4.5 with convergence set at 0.00001.
- Multiple starting values and multi-indexes were used to ensure convergence to the global optimum.
- The upward F-test procedure of Eastwood and Gallant (1991) is used to determine the degree of the Fourier polynomials with  $A = 4$  and  $J = 1$ .

## Appendix 3a

## Income Elasticities of Demand

Year	Food		Other Services		Rents		Divisia Fuel and Transportation		Divisia Alcohol and Tobacco		Divisia Clothing, Durable Household Goods & Other Goods	
	SR	LR	SR	LR	SR	LR	SR	LR	SR	LR	SR	LR
1923	0.630	0.726	0.591	0.616	0.280	0.346	1.517	1.031	0.488	0.509	1.592	1.229
1924	0.617	0.690	0.560	0.588	0.303	0.362	1.570	1.051	0.439	0.477	1.822	1.184
1925	0.489	0.707	0.577	0.602	0.321	0.378	1.583	1.093	0.478	0.518	1.621	1.275
1926	0.612	0.703	0.549	0.623	0.280	0.357	1.655	1.388	0.465	0.566	1.627	1.137
1927	0.548	0.706	0.567	0.605	0.275	0.315	2.016	1.549	0.457	0.525	1.842	1.157
1928	0.604	0.703	0.568	0.586	0.324	0.364	1.850	1.435	0.459	0.550	1.546	1.204
1929	0.489	0.818	0.538	0.569	0.304	0.362	2.036	1.532	0.479	0.451	1.592	1.164
1930	0.647	0.823	0.542	0.576	0.362	0.437	1.646	1.434	0.421	0.460	1.683	1.144
1931	0.587	0.780	0.575	0.629	0.387	0.452	1.913	1.351	0.414	0.527	1.736	1.172
1932	0.599	0.709	0.603	0.624	0.370	0.442	1.642	1.147	0.410	0.484	1.587	1.314
1933	0.639	0.755	0.568	0.618	0.392	0.447	1.802	1.322	0.477	0.526	1.570	1.275
1934	0.582	0.737	0.568	0.640	0.422	0.484	1.838	1.434	0.492	0.548	1.806	1.288
1935	0.680	0.793	0.535	0.634	0.359	0.493	1.842	1.456	0.431	0.448	1.638	1.274
1936	0.627	0.807	0.586	0.623	0.305	0.533	1.857	1.377	0.378	0.511	1.720	1.223
1937	0.617	0.825	0.541	0.637	0.432	0.517	1.826	1.346	0.415	0.466	1.557	1.355
1938	0.521	0.745	0.611	0.591	0.444	0.474	2.041	1.390	0.364	0.545	1.700	1.315
1939	0.699	0.777	0.583	0.606	0.473	0.414	1.745	1.775	0.416	0.450	2.956	2.207
1940	0.821	0.879	0.601	0.583	0.473	0.376	1.929	1.781	0.439	0.428	2.782	2.230
1941	0.730	0.748	0.702	0.701	0.612	0.622	1.523	1.643	0.374	0.352	3.117	2.946
1942	0.958	0.939	0.681	0.758	0.686	0.668	1.647	1.585	0.399	0.416	2.788	2.644
1943	0.932	0.838	0.703	0.700	0.758	0.716	1.680	1.700	0.526	0.505	2.606	2.684
1944	0.890	0.834	0.681	0.670	0.631	0.625	1.715	1.735	0.467	0.494	2.763	2.722
1945	0.923	0.910	0.630	0.696	0.676	0.694	1.768	1.947	0.526	0.557	3.097	2.424
1946	0.753	0.980	0.610	0.655	0.525	0.635	1.924	1.665	0.394	0.467	2.623	2.536
1947	0.757	0.877	0.584	0.631	0.611	0.671	1.966	1.686	0.355	0.474	2.673	2.440
1948	0.657	0.768	0.558	0.627	0.636	0.706	1.635	1.576	0.398	0.438	2.564	2.583
1949	0.695	0.792	0.559	0.614	0.526	0.666	1.664	1.554	0.496	0.466	2.674	2.338
1950	0.678	0.700	0.595	0.615	0.653	0.743	1.910	1.460	0.358	0.534	2.948	2.306
1951	0.906	0.810	0.548	0.593	0.562	0.692	1.978	1.658	0.475	0.516	2.589	2.479

(continues)

*(continued)*

Year	Food		Other Services		Rents		Divisia Fuel and Transportation		Divisia Alcohol and Tobacco		Divisia Clothing, Durable Household Goods & Other Goods	
	SR	LR	SR	LR	SR	LR	SR	LR	SR	LR	SR	LR
1952	0.947	0.752	0.560	0.637	0.586	0.696	1.994	1.660	0.336	0.575	3.122	2.532
1953	0.669	0.826	0.624	0.640	0.596	0.716	2.025	1.668	0.497	0.518	3.213	2.750
1954	0.813	0.874	0.632	0.639	0.638	0.798	1.889	1.666	0.338	0.581	3.486	2.960
1955	0.864	0.968	0.616	0.662	0.661	0.858	2.044	1.684	0.434	0.534	3.323	3.049
Min	0.489	0.690	0.535	0.569	0.275	0.315	1.517	1.031	0.336	0.352	1.546	1.137
Max	0.958	0.980	0.703	0.758	0.758	0.858	2.044	1.947	0.526	0.581	3.486	3.049
Avg	0.702	0.797	0.592	0.630	0.481	0.547	1.808	1.508	0.433	0.497	2.302	1.925

<sup>a</sup> Estimates are from the Fourier flexible form share equations (2) and parameter estimates.<sup>b</sup> The income elasticities are statistically significantly different from zero at the 5% level.

## Appendix 3b

### Own-Price Elasticities of Demand

Year	Food		Other Services		Rents		Divisia Fuel and Transportation		Divisia Alcohol and Tobacco		Divisia Clothing, Durable Household Goods & Other Goods	
	SR	LR	SR	LR	SR	LR	SR	LR	SR	LR	SR	LR
1923	-0.188	-0.218	-0.052	-0.110	-0.257	-0.357	-0.596	-0.777	-0.411	-0.675	-0.660	-0.485
1924	-0.163	-0.265	-0.078	-0.133	-0.305	-0.405	-0.602	-0.705	-0.417	-0.644	-0.588	-0.354
1925	-0.130	-0.279	-0.069	-0.136	-0.281	-0.381	-0.613	-0.802	-0.423	-0.692	-0.531	-0.366
1926	-0.209	-0.269	-0.088	-0.145	-0.373	-0.394	-0.694	-0.775	-0.378	-0.626	-0.663	-0.347
1927	-0.193	-0.244	-0.201	-0.226	-0.312	-0.412	-0.589	-0.784	-0.492	-0.665	-0.623	-0.233
1928	-0.194	-0.298	-0.216	-0.276	-0.269	-0.369	-0.611	-0.712	-0.450	-0.703	-0.616	-0.360
1929	-0.127	-0.284	-0.165	-0.223	-0.343	-0.404	-0.656	-0.730	-0.489	-0.677	-0.520	-0.377
1930	-0.147	-0.310	-0.091	-0.197	-0.284	-0.384	-0.665	-0.783	-0.503	-0.686	-0.689	-0.323
1931	-0.175	-0.267	-0.112	-0.202	-0.313	-0.413	-0.604	-0.763	-0.404	-0.707	-0.687	-0.311
1932	-0.123	-0.283	-0.152	-0.212	-0.280	-0.380	-0.665	-0.714	-0.511	-0.642	-0.562	-0.324
1933	-0.216	-0.289	-0.099	-0.220	-0.353	-0.396	-0.661	-0.730	-0.399	-0.625	-0.770	-0.322
1934	-0.152	-0.256	-0.074	-0.184	-0.307	-0.407	-0.637	-0.719	-0.401	-0.628	-1.214	-0.295
1935	-0.157	-0.241	-0.061	-0.125	-0.320	-0.420	-0.624	-0.737	-0.431	-0.588	-1.153	-0.243
1936	-0.192	-0.235	-0.093	-0.136	-0.261	-0.286	-0.583	-0.747	-0.569	-0.712	-1.460	-0.328

*(continues)*

*(continued)*

Year	Food		Other Services		Rents		Divisia Fuel and Transportation		Divisia Alcohol and Tobacco		Divisia Clothing, Durable Household Goods & Other Goods	
	SR	LR	SR	LR	SR	LR	SR	LR	SR	LR	SR	LR
1937	-0.209	-0.274	-0.076	-0.140	-0.290	-0.261	-0.660	-0.827	-0.438	-0.676	-0.876	-0.542
1938	-0.135	-0.277	-0.083	-0.148	-0.287	-0.387	-0.653	-0.732	-0.426	-0.630	-1.136	-0.410
1939	-0.399	-0.424	-0.165	-0.201	-0.504	-0.486	-0.750	-0.783	-0.438	-0.628	-1.457	-0.771
1940	-0.391	-0.458	-0.176	-0.238	-0.436	-0.403	-0.844	-0.851	-0.616	-0.605	-1.855	-0.827
1941	-0.402	-0.486	-0.192	-0.215	-0.482	-0.492	-0.939	-0.841	-0.830	-0.717	-1.531	-1.260
1942	-0.344	-0.374	-0.159	-0.204	-0.560	-0.529	-0.913	-0.893	-0.878	-0.811	-1.775	-0.942
1943	-0.616	-0.556	-0.201	-0.191	-0.387	-0.687	-0.877	-0.913	-0.742	-0.752	-2.306	-1.162
1944	-0.430	-0.561	-0.216	-0.227	-0.336	-0.586	-0.804	-0.881	-0.715	-0.722	-1.846	-1.477
1945	-0.508	-0.430	-0.252	-0.240	-0.448	-0.648	-0.816	-0.871	-0.622	-0.783	-2.110	-1.605
1946	-0.150	-0.196	-0.179	-0.282	-0.331	-0.631	-0.675	-0.911	-0.416	-0.573	-2.510	-1.803
1947	-0.183	-0.207	-0.181	-0.238	-0.682	-0.782	-0.893	-0.969	-0.560	-0.586	-2.394	-1.615
1948	-0.222	-0.246	-0.093	-0.144	-0.542	-0.842	-0.787	-0.954	-0.459	-0.679	-2.152	-1.883
1949	-0.170	-0.221	-0.107	-0.139	-0.633	-0.933	-0.822	-0.842	-0.545	-0.761	-2.736	-1.821
1950	-0.215	-0.236	-0.065	-0.118	-0.573	-0.873	-0.679	-0.874	-0.562	-0.638	-2.688	-1.950
1951	-0.202	-0.250	-0.069	-0.122	-0.428	-0.793	-0.818	-0.867	-0.485	-0.688	-2.159	-1.696
1952	-0.231	-0.287	-0.036	-0.139	-0.668	-0.968	-0.744	-0.957	-0.550	-0.797	-1.890	-1.825
1953	-0.218	-0.297	-0.015	-0.142	-0.618	-0.918	-0.775	-0.897	-0.522	-0.882	-1.696	-1.487
1954	-0.174	-0.315	-0.054	-0.097	-0.601	-0.930	-0.649	-0.811	-0.581	-0.897	-1.882	-2.037
1955	-0.196	-0.338	-0.057	-0.081	-0.485	-0.785	-0.639	-0.718	-0.615	-0.948	-1.488	-1.637
Min	-0.616	-0.561	-0.252	-0.282	-0.682	-0.968	-0.939	-0.969	-0.878	-0.948	-2.736	-2.037
Max	-0.123	-0.196	-0.015	-0.081	-0.257	-0.261	-0.583	-0.705	-0.378	-0.573	-0.520	-0.233
Avg	-0.235	-0.308	-0.119	-0.177	-0.410	-0.556	-0.713	-0.814	-0.524	-0.698	-1.431	-0.952

<sup>a</sup> Estimates are from the Fourier flexible form share equations (2) and parameter estimates.<sup>b</sup> The own-price elasticities of demand are statistically significantly different from zero at the 5% level.