(In)Stability of the relationship between relative expenditure and prices of durable and non-durable goods

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(In)Stability of the Relationship between Relative Expenditure and Prices of Durable and Non-durable Goods

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Abstract

This study shows that, in a model with non-separable preferences for durable and non-durable goods, the effect of relative prices on the ratio of consumption for the two goods, known as the intratemporal elasticity of substitution, has decreased in the U.S. since 1981. We found that durable and non-durable goods were gross substitutes until 1981 and have been gross complements in the period after that. This break also had significant implications for short-term consumption dynamics. Although durable goods still drive most of the adjustment towards long-term equilibrium in non-durables, durables, and relative prices, the size of the adjustment has significantly decreased in the post-1981 period, suggesting slower convergence towards long-run equilibrium. Additionally, we found that the durable goods cycle has become more persistent over time. During the recent pandemic, durable goods were more than 20% above the long-term common trend that they share with non-durable goods and their relative prices. The findings of this study also have implications for the global supply chain pressures that have contributed to rapid inflation in the post-COVID period. The estimated durable goods cycle and the Global Supply Chain Pressure Index exhibit a non-linear relationship, where a deviation of more than 4.8% from the long-term common trend leads to a significant increase in the supply chain pressure index.

Keywords: Durable Goods Consumption, Intratemportal Elasticity of Substitution, Structural Break, Trend Cycle Decomposition.

JEL Codes: E21, E23, E32, E52

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1 Introduction

The COVID-19 pandemic had a major impact on consumer behavior and spending patterns, resulting in a disproportionate increase in expenditure on durable goods compared to non-durables. For instance, year-over-year growth in real expenditure on durable goods rose dramatically from the third quarter of 2020, peaking at 34.6% in 2021Q2. In contrast, the growth in real expenditure on non-durable goods was much less prominent during this period, with a peak of 14.6% in 2021Q2.[1] Although durable goods are typically more sensitive to business cycles, their response was further amplified by the nature of the pandemic-induced recession and the response of governments/employers to curb the spread of COVID-19. For example, limits on public gatherings, remote work, and government stimulus may have all contributed to the dramatic increase in durable goods spending during this period.

This extraordinary response of durable good spending to the pandemic generated active interest in both policy and business news sector, with most commentators focusing on inflationary aspect of excessive spending on various kinds of durable goods.[2] In this paper, we argue that the nature of durable goods spending, especially in relation to non-durable goods, may have changed over a longer period in response to the changing economic environment in the U.S. For instance, the period since the mid-1980s is characterized by low and stable inflation, which theoretically relaxes household budget constraints by increasing real incomes and allowing them to replenish their goods stock at a higher rate than earlier. Additionally, the historical decline in real interest rates that peaked in the early 1980s can also influence durable goods spending disproportionately by lowering the user cost of the service flow from such purchases.[3] Moreover, the financial innovations and de-regulation of financial markets since the 1990s have substantially increased access to retail debt instruments that are typically used to fund durable goods purchases. This backdrop raises the

[1]Based on authors calculations from the FRED database.

[2]See LaBelle and Santacreu (2022). There are several articles in business media on this topic. See for example, https://www.economist.com/finance-and-economics/2022/01/22/just-how-gummed-up-are-supply-chains.

[3]Durable goods spending is much more sensitive to interest rate changes than non-durable consumption (Ogaki and Reinhart, 1998).

question of whether the long-term equilibrium relationship between durable and non-durable goods consumption has changed over time and what implications any break in this relation may have for short-run consumption dynamics. In this paper we argue that one way to interpret the recent increase in durable goods spending is to draw from the literature on intertemporal consumption model with durable goods that allows us to quantify changes in durable good spending as a deviation from the long-term trend it shares with non-durable spending. Understanding and appropriately accounting for this dynamics would provide a new perspective on the temporary or permanent nature of the recent spike in durable goods spending and help better assess its impact on the U.S. economy.

There is a rich literature in macroeconomics that offers guidance on the relationship between durable and non-durable goods spending.[4]. For example, Ogaki and Reinhart (1998) extended the intertemporal consumption model of Hall (1979) by considering the case of non-separable utility from in durable and non-durable goods. Using quarterly data for the U.S. from 1951Q1-1983Q4, they captured the implied long-run relationship from their model in a cointegration framework. They report an elasticity of substitution between durable and non-durable goods close to one, which has an important implication. A one percent change in the relative price of durable goods will be completely offset by a one percent change in the opposite direction in the relative volumes of the two goods. As a result, the relative price changes would have no impact on the nominal expenditure ratio for durable and non-durable goods.

In panel (a) of Figure 1, we provide the evolution of the expenditure ratios, real and nominal, for the two goods from 1959Q1 through 2021Q4. We observe that the ratio of real expenditure on non-durable and durable goods has declined monotonically over our sample period. In the literature, the decline has been attributed to a corresponding downward trend in the relative price of durable goods (see Ogaki and Reinhart (1998), Pakos (2014), among others) In panel (b), we confirm this decline in the relative price ratio of the two goods. However, as can be observed from panel (a), the nominal expenditure ratio exhibits no trend

[4]See Hall (1988), Mankiw (1985), Hansen and Singleton (1996) for the literature on additive separable consumption in durable and non-durable goods

for most of the sample but starting in the late 1990s this ratio increases sharply before settling at this high level. Moreover, there was a precipitous decline in both ratios during the COVID-19 period driven by the excessive demand for durable goods. The dynamics reported in Figure 1 raise the question of stability in the relationship between relative prices and relative expenditures of durable and non-durable goods.

In this paper, we aim to answer three related questions. First, is there a structural break in the long-term relationship between the expenditure ratio and relative prices of durable and non-durable goods? Second, what does such a break imply about the intratemporal elasticity of substitution between non-durable and durable goods? Specifically, can a change in this parameter value explain the shift in the nominal expenditure ratio observed in the later part of the sample in Figure 1? Finally, has the nature of the durable goods cycle changed in the recent period? By addressing these questions about the potential break in the equilibrium relationship between non-durable and durable goods consumption, we can provide useful new information on the time it will take for the durable goods stock to adjust back to pre-pandemic levels.[5]

Methodologically, we extend the work of Ogaki and Reinhart (1998) by allowing for structural breaks in the dynamics of relative consumption and prices of durable and non-durable goods. To do so, we utilize the framework proposed by Kejriwal and Perron (2010) for testing and dating multiple breaks in the cointegrating vector. Our analysis reveals evidence for a single break in the equilibrium relationship between the expenditure and prices of the two goods in the fourth quarter of 1981. Using this break date, we identify two regimes for durable and non-durable consumption dynamics in the US: 1959Q1-1981Q4 and 1982Q1-2021Q4. Furthermore, our analysis indicates a decline in the intratemporal elasticity of substitution between durable and non-durable goods, from 1.12 in the first sample period to 0.763 in the second regime. This decline in intratemporal elasticity of substitution between durables and non-durables after 1981 coincided with other structural changes in the U.S. economy that have been documented by academic research. For example, McConnell

[5]Note that our focus is on the deviation of the level of the real durable good expenditure from the common trend it shares with real expenditure on non-durable and their relative prices.

and Perez-Quiros (2000) and Kim and Nelson (1999) find evidence of structural breaks in major macro variables, while Bernanke (2003) suggests that long-term inflation expectations became anchored in the mid-90s. Additionally, studies have shown the impact of financial development on consumption behavior. Dynan et al. (2006) find that financial innovation, such as developments in lending practices and loan markets that have enhanced the ability of households and firms to borrow, as well as changes in government policy, such as the demise of Regulation Q, have played a role in the observed moderation in economic activity, including consumer spending.[6]. Although our study does not provide a causal framework for interpreting the decline in intratemporal elasticity of substitution, such a decline is consistent with the idea that structural changes in the economy have made consumption less sensitive to business cycles.

To better understand the implications of our finding regarding the break in the long-run equilibrium relationship between durable and non-durable goods, we use a vector error correction model (VECM) to examine potential changes in the short-run transition dynamics. We estimate the VECM separately for each of the two sample periods identified by our break analysis and investigate which variables dominate the error correction process in the short run. Our results show that, for both sample periods, the growth of durable good expenditure accounts for most of the error correction, while there is limited evidence of error correction from other variables. Given the dominant role played by durable goods in the error correction process, changes in the persistence of durable goods cycles could have significant implications for aggregate consumption response to cyclical fluctuations, such as the pandemic. To further investigate this, we implement a multivariate Beveridge-Nelson Decomposition to decompose durables expenditure, non-durables expenditure and relative price of durable goods into trend and cycle components. There are several finding of interest. First, the cyclical component of durable goods is much larger than that of the other two time series in our model, consistent with the literature where durable goods spending is found to be more cyclical in nature than

[6] Bhatt et al. (2020) document significant time variation in the proportion of rule-of-thumb consumers in the US starting in early 1980s consistent with a relaxation in budget constraint for a higher proportion of households in the U.S.

non-durable goods. Further, our estimated durable goods cycle captures the boom and bust of the US business cycles. Second, we find that the dynamics of the durable goods cycle has changed and has become much more persistent in the recent time period. Finally, our estimates show that durable goods consumption during the pandemic was at a historic high relative to its trend, with a 24 percent increase above its long-run trend.

To further supplement this analysis, we use the local projections approach and estimate the dynamic response of durable good consumption to a shock in the cointegrating residual. We find that in the pre-1982 period durable goods responded much more quickly with a peak around 6 quarters. In contrast in the post-1982 period this response has been much slower and persistent, with a peak at 16 quarters and does not become statistically insignificant even at a 6-year horizon. This confirms that the nature of the adjustment of durable goods to any disequilibrium in the relationship has changed and it now takes much longer for any shock to that long-run relationship to be corrected.[7] Our findings have important implication for assessing the dynamic path of the pandemic driven shock to durable goods spending. Although we find that a large part of durable spending growth is cyclical, there has been an increase in the persistence of this cycle which would imply a much slower speed of reversion back to the long run trend. This has implications for business cycles volatility and monetary policy. Monetary policy affects the economy through various channels, including consumer spending. Our findings suggest that the lag in the effect of monetary policy on consumer spending on durable goods may have increased recently. Our results are also supportive of the recent research on intertemporal shifting of durable goods demand where the dynamics of demand for durable goods create a propagation mechanism that makes changes in real interest rates very persistent[8].

[7] In contrast we do not find any significant response of non-durable goods at all horizons in the later time period, and a significant but short lived response in the first time period.

[8] For example, McKay and Wieland (2021) argue that expansionary monetary policy shifts the adjustment thresholds, accelerating adjustments by those who were close to an adjustment threshold. For instance, low interest rates may prompt some households to accelerate the purchase of a new car. In the subsequent periods, they no longer need to purchase a car as they have already done so. As a result, aggregate demand is weaker in periods following the stimulus. This is consistent with persistent negative cycles in the aftermath of the Great Financial Crisis of 2008-09. See also Leamer (2007, 2009) and Hall (2011) among others.

The remainder of the paper is structured as follows. Section 2 provides a brief literature review followed by the conceptual framework in section 3. Section 4 presents the data used in the study. Empirical analysis in section 5 contains the results of the paper. Section 6 discusses policy implications and conclusions are presented in Section 7.

2 Brief Literature Review

The literature on durable goods consumption has mainly focused on two directions. The first strand focuses on the role of durable goods expenditure in intertemporal models of consumption. The papers in this literature initially examined the time series properties of durable goods consumption in the context of intertemporal models of consumption. The framework of this work was based on the seminal contribution of Hall (1978), which examined the intertemporal behavior of non-durable goods and services consumption. See Mankiw (1982) and Startz (1989) among others for a nice discussion of the time series properties of durable goods consumption. The literature on intertemporal models of consumption then proceeded to estimate the intertemporal elasticity of substitution - the response of consumption and saving to real interest rate. Hall (1988) showed that the data for the twentieth century showed no strong evidence that the elasticity of intertemporal substitution is positive. Hansen and Singleton (1996) improved on Hall's inference methods and found similar results. Ogaki and Reinhart (1998) argue that the model used by Hall (1998) and Hansen and Singleton (1996) is misspecified because the intratemporal substitution between non-durable consumption goods and durable consumption goods is ignored. They use a two-step procedure that combines a cointegration approach to preference parameter estimation with generalized method of moments to take these effects into account. They find that the estimates for the intertemporal elasticity of substitution are positive and significantly different from zero, even when time aggregation is taken into account. Our objective in this paper is not to estimate the intertemporal elasticity of substitution but instead to use the theoretical framework proposed by Ogaki and Reinhart (1998) to examine the dynamic relationship between non-durable goods, durable goods, and relative prices. In particular, we exploit the theoretical relationship that estimates intratemporal elasticity of substitution between non-durable goods and durable stock and estimate the dynamic behavior of durable and non-durable goods consumption in the US economy.[9][10]

Our paper contributes to the empirical literature on modeling durable goods expenditure in the United States. This line of research aims to explain the cyclical nature of durable goods consumption, which has been a topic of interest for decades. Many of these models are based on the permanent income hypothesis proposed by Friedman (1957) and Ando and Modigliani (1963). For example, Hymans (1970a, 1970b) examined the role of consumer sentiment and wealth in the evolution of consumer spending, while Bar Ilan and Blinder (1987) found that expenditures on durables are highly responsive to changes in permanent income. Leamer (2009) investigated the relationship between cycles in durable goods and housing, and proposed that a monetary rule targeting housing could also alleviate the cycle in consumer durables. More recently, Zandweghe and Braxton (2013) studied the slow recovery after the 2008-09 financial crisis and found that durable goods spending became less sensitive to changes in interest rates. Hall (2011) argued that this weak response is related to the zero lower bound on nominal interest rates, which limits the room for a decline in the real interest rate in a low-inflation economy.

Our paper also extends the econometrics literature that has been developed to test for structural breaks in cointegrating relationships by providing an application in the intertemporal consumption setting. Estimation of long-run relationship is performed using the cointegration methodology developed by Engle and Granger (1989). This method assumed a time invariant long-run relationship. As widely known, macroeconomic variables are prone to structural break in relationships. To take into account these breaks, Kejriwal and Perron (2010) developed an econometric framework that handles structural break in cointegrating relationship. We apply this methodology to the theoretical long-run relationship between

[9] It should be noted that Ogaki and Reinhart (1998) derived the long-run equilibrium relationship between consumption ratios and relative prices on the assumption of homothetic preferences. Pakos (2014) modified their model and introduced nonhomotheticity in the utility function.

[10] Researchers have also examined the role of wealth in these models. For example, see Atkeson and Ogaki (1996).

relative consumption and relative prices in this paper.

3 Conceptual Framework

3.1 A simple model of non-durable and durable good consumption

Our conceptual framework follows Ogaki and Reinhart (1998) who use a cointegration-Euler equation approach to estimate intertemporal elasticity of substitution with non-separable preferences in non-durable and durable goods. A representative consumer maximizes the following lifetime utility (LTU) given by:

$$LTU = E_0 \left[\sum_{t=0}^{\infty} \beta^t \left(\frac{1}{1 - 1/\sigma} \right) u(C_t, S_t)^{1-\frac{1}{\sigma}} \right] \tag{1}$$

Here, C_t denote consumption of non-durable good and S_t denotes the service flow from the purchase of durable good. Preference parameters β and σ capture the discount factor and intertemporal elasticity of substitution, respectively. The intraperiod utility is assumed to be a constant elasticity function given by:

$$u(C_t, S_t) = [a \cdot C_t^{1-1/\gamma} + S_t^{1-1/\gamma}]^{\frac{1}{1-1/\gamma}} \tag{2}$$

Here, a is the preference parameter capturing the weight assigned to non-durable good and γ represents the elasticity of substitution between the non-durable good and the service flow from the durable good. Assuming a depreciation rate of δ, the relationship between durable good purchase and the flow of services it generates is given by:

$$S_t = D_t + (1 - \delta)D_{t-1} + (1 - \delta)^2 D_{t-2} .... \tag{3}$$

Let P_t denote the relative price of the durable good, assuming that the non-durable good is the numeraire in each period. Let R_{t+1} denotes the gross rate of return on a financial asset. Then, the user cost for the service flow of the durable good (denoted by Q_t) is given by:

$$Q_t = P_t - (1 - \delta) \cdot E_t \left[P_{t+1} \cdot R_{t+1} \right] \tag{4}$$

The intratemporal first order condition implied by the preference specification of period utility in equation (2) simply equates the marginal utilities of every dollar spent between durable and non-durable goods:

$$a \cdot C_t^{-1/\gamma} = \frac{S_t^{-1/\gamma}}{Q_t} \tag{5}$$

Ogaki and Reinhart (1998) use equation (5) above and show that $[log(C_t/D_t), log(p_t)]$ is cointegrated with a cointegrating vector of $[1, -\gamma]$.[11] This gives us the following cointegrating relationship between non-durable and durable good consumption and their relative prices:

$$log(C_t/D_t) = \alpha + \gamma \cdot log(P_t) + \epsilon_t \; where \; \epsilon_t \sim I(0) \tag{6}$$

3.2 Structural breaks in the cointegrating vector

An important consideration when estimating the long-term relationships implied by cointegration is the possibility of shifts in the parameters of the cointegrating vector. Due to various changes witnessed in the U.S. economy over last six decades, it is reasonable to argue that cointegrating relationship among the variables we are investigating are likely to experience structural breaks. In the presence of such breaks, conventional cointegration tests are inappropriate as they assume the cointegrating vector to be time-invariant. In such a case, one may falsely conclude that there is no long-term relationship between a set of non-stationary variables. Hansen (1992) provides a framework for testing for a single unknown break in the cointegrating vector using sup, mean, and exp-LM tests. However, these tests

[11] Like Ogaki and Reinhart (1998), our analysis also assumes homothetic preferences. Okuba (2008) and Pakos (2004, 2011) extend this framework for non-homothetic preferences. In the presence of strong non-homotheticity, our estimate of γ would be biased. In the literature the effect of non-homotheticity on the estimates of the intratemporal substitution elasticity is mixed. For example, Atkesan and Ogaki (1996) incorporated a particular type of non-homotheticity by adding subsistence level of consumption to the utility and found no significant effect on the estimates of intratemporal elasticity. In contrast, Pakos (2011) introduces a different type of non-homotheticity and found estimates in the range of 0.17-0.19. In this paper we abstract away from this issue due to our focus of documenting change in this elasticity over time. Due to small number of observations for any regime identified by the structural break test, we obtain theoretically incorrect values of preference parameters when we follow Pakos (2011). This issue of sample size sensitivity of preference parameters when using Pakos's framework is also noted by others in the literature (e.g. see Okuba (2011)).

have non-monotonic power in finite sample sizes. Furthermore, in the presence of multiple breaks, the power of this test could be very low. Kejriwal and Perron (2010) propose a simple testing framework that overcomes both of these issues and provide a sequential procedure for estimating the number of breaks in the cointegrating vector. In this section, we present a simple representation of their framework as applicable to our cointegration regression model described in equation (5). We begin by allowing for a break in the parameter γ in our analysis as follows:

$$log(C_t/D_t) = \alpha_j + \gamma_j \cdot log(P_t) + \nu_t \quad t = T_{j-1}+1, ..., T_j \; j = 1, 2, ..., m+1 \tag{7}$$

Here, we allow for $m+1$ regimes for both parameters, T is the sample size. Then, the null hypothesis of parameter stability is given by:

$$H_0 : \alpha_j = \alpha, \gamma_j = \gamma \; \forall j$$

Kejriwal and Perron (2010) propose a UD-max test that takes the maximum of the sup-Wald statistics allowing for up to fiver breaks.[12] A rejection based on the UD-max statistic provides evidence for break in the cointegrating vector and a sequential procedure is used to determine the number of breaks.

4 Data and Descriptive Statistics

We use quarterly consumption data from the National Income and Product Accounts (NIPA) available from the Bureau of Economic Analysis website covering the time period from 1959Q1 through 2021Q4. We define non-durable good consumption by adding personal consumption expenditure (PCE) on nondurable goods and services.[13] Consumer durable

[12]Following Kejriwal and Perron (2010) we set the trimming level at 15% and account for endogeneity of regressors by adding four leads and lags of all regressors in our model. Their procedure also accounts for serial correlation.

[13]In our analysis we include services as part of the non-durable goods following the convention in the literature (see Ogaki and Reinhart (1998), Pakos (2014)). However, our findings are robust to alternative definitions of what constitutes a non-durable good. For instance, the significant decline in the intratemporal elasticity of substitution reported in this paper is also observed when we exclude services from the definition

goods include motor vehicles, furniture, recreation, and miscellaneous category. All data were converted to real values using the price indexes for PCE (2012=100). The relative price of consumer durables is calculated as the ratio of this index on durable goods to that of the non-durable goods. We use population data from the Federal Reserve Bank of St. Louis to compute per capita real consumption expenditures for durable and non-durable goods. Finally, to compute real stock of the durable goods we first specify the following law of motion for durable good stock at the quarterly frequency:

$$D_{qt} = (1 - \delta_t) \cdot D_{q-1t} + E_{qt} \tag{8}$$

Here D_{qt} denotes durable good stock and E_{qt} denotes real PCE on durable goods for quarter q in year t[14]. Next, we follow Levy and Chen (1994) and utilize the publicly available data on annual stock of durable goods from NIPA to estimate the depreciate rates in equation (8) and use them to construct quarterly durable stock data. Note that using this method the fourth quarter durable stock estimates will equal the corresponding year end value available from NIPA.

In Figure 1 we plot the relative non-durable and durable good expenditure (real and nominal values). We find that although there is a secular decline in the real expenditure ratio, the nominal ratio is stationary in different sub-samples. In the literature this has been attributed to the corresponding decline in the relative price of durable goods leading to a substitution away from non-durable goods in favor of durable goods. In Figure 2 we confirm this stylized fact about relative expenditure and price dynamics in the US. As long as the elasticity of substitution between durable and non-durable goods is unity, the decline

of non-durable goods. In contrast, when we define non-durable goods to only include services, we find no such decline in this elasticity parameter. This seem to indicate that the changing nature of the long-term relationship between relative consumption of non-durable and durable goods and the relative price of durable goods seems to be driven by the changing dynamics of non-durable goods excluding services and durable goods. This is not surprising because in real terms, the share of services in total real consumption expenditure has been more or less constant over our sample period. In contrast, the share of durable goods expenditure has risen and that of non-durable goods has fallen. For brevity, these results are not included in the manuscript but are available upon request.

[14] Following the convention in this literature we assume a constant quarterly depreciation rate for a given year and denote it by δ_t. See Chah et al (1995), Ogaki and Reinhart (1998), Yogo (2006)

in relative price of durable goods would not impact the nominal expenditure ratio. However, as we note from Figure 1, in the latter part of our sample there seem to be a positive level shift in the nominal expenditure ratio. One possible explanation for this changing dynamics of the nominal expenditure ratio could be a decline in the elasticity of substitution between durable and durable goods. In the next section we provide evidence that the elasticity of substitution between durable and non-durable goods is less than unity in the latter part of our sample.

5 Empirical Results

5.1 Structural Break in Long-Run Relationship

In Table 1 we provide the results for the Kejriwal and Perron (2010) UD-max test for cointegration with multiple breaks.[15] We reject the null hypothesis of parameter stability in equation (6). We also supplement the UD-max test with the LM-type test for the null hypothesis of cointegration with breaks against the alternative of no breaks.[16] Again we find evidence for cointegration with breaks in our sample. Using the sequential procedure suggested by Kejriwal and Perron (2010), we find a single break in the cointegrating vector in 1981Q4. This suggests existence of two regimes in the long term relationship between real expenditure to durable stock ratio and the relative price of durable goods. The first regime covers the sample period 1959Q1-1981Q4 and the second regime covers 1982Q1-2021Q4.

We estimate equation (6) for these two sample periods using the fully modified OLS and present our results in Table 3.[17] We find that for both sample periods, the coefficient on relative price is positive and statistically significant. Given our utility function specification, this parameter has the interpretation of intratemporal elasticity of substitution between non-

[15]Before testing for cointegration, we conduct the ADF unit root tests for the natural logarithm of relative durable price (p_t), real non-durable expenditure per capita (c_t), and durable good stock (d_t). We find that all variables are difference stationary.

[16]See Kejriwal (2008) for a multiple breaks extension of the single break LM test proposed by Arai and Kurozumi(2007).

[17]Using Park (1992) method of canonical cointegrating regressions yield similar estimates of the cointegrating vector in each sample period.

durable goods and durable goods. Our estimates suggest that in the second period of our sample, the degree of substitution has declined and is significantly less that 1. In contrast, for the first time period this elasticity is greater than 1.[18] This finding suggests that there has a been an economically meaningful shift in the nature of relationship between durable and non-durable consumption, with these two goods being gross substitutes in the first regime, and gross complements since 1981.

A causal analysis of identifying the mechanisms underlying the change in the nature of the relationship between non-durable and durable goods is beyond the scope of our paper and we believe that would be a fruitful avenue for future research. Here we provide a few reasonable pathways that can help rationalize this shift by drawing from various changes in the economic environment in the U.S. since early 1980s. For example, starting early 1980s, the US economy has experienced great moderation with lower volatility and stable, low rate of inflation. Similarly, this period also coincided with the historical decline in real interests that affect durable goods consumption disproportionately more than non-durable goods. Finally, financial deregulation and easy access to retail credit also impact durable goods purchases more directly. These developments can impact the way people approach durable goods purchases by easing the budget constraint that can have the impact of increasing purchases for both durable and non-durable goods.

5.2 Short-run Adjustment

In the previous section we document a break in the long run relationship between real expenditure ratio and relative prices of non-durable and durable goods. We now investigate whether there has been a corresponding shift in the short run dynamics as well in terms of which variables error correct deviations from the shared common trend in non-durable, durables and relative prices? Are they primarily a result of transitory movements in durable consumption or of transitory movements in non-durable consumption and relative prices?

[18] We also examine the sensitivity of our results for the second sub-sample by excluding the pandemic period and estimating the model for 1982Q1-2019Q4 and the estimated cointegration vector for relative price is 0.74. This suggests that the pandemic did not have any significant impact on the long-run relationship between relative consumption and relative prices presented here.

To answer these questions, we estimate a Vector Error Correction model (VECM) for each sub-sample separately. The Engle and Granger representation theorem provides a VECM representation of the cointegrated system. The VECM model has the following representation

$$\Phi(L)\triangle z_t = \Phi_0 + \Pi z_{t-1} + u_t \tag{9}$$

where $\Phi(L) = I_n - \sum_{k=1}^{p-1} \Phi_k$ and $\Pi = \pi\beta'$ where $\pi = (\pi_c, \pi_d, \pi_p)'$ is the error-correction vector and $\beta = (1, -1, -\gamma)'$ is the cointegrating vector.[19] Using Bayesian information criterion (BIC) we determine that the optimal lag length $p = 2$ such that our VECM representation below has only one lag:

$$\triangle c_t = \phi_{10} + \phi_{11}\triangle c_{t-1} + \phi_{12}\triangle d_{t-1} + \phi_{13}\triangle p_{t-1} + \pi_c\beta' z_{t-1} + u_{ct} \tag{10}$$

$$\triangle d_t = \phi_{20} + \phi_{21}\triangle c_{t-1} + \phi_{22}\triangle d_{t-1} + \phi_{23}\triangle p_{t-1} + \pi_d\beta' z_{t-1} + u_{dt} \tag{11}$$

$$\triangle p_t = \phi_{30} + \phi_{31}\triangle c_{t-1} + \phi_{32}\triangle d_{t-1} + \phi_{33}\triangle p_{t-1} + \pi_p\beta' z_{t-1} + u_{pt} \tag{12}$$

where $\beta' z_{t-1} = c_{t-1} - \alpha - d_{t-1} - \gamma p_{t-1}$ is the disequilibrium error from the last period. π_c, π_d, π_p capture the adjustment coefficients of each variable based on the deviation from their shared long-run relationship. According to the Engle-Granger theorem, if there exists a cointegrating relationship then at least one of these $\pi's$ must be significant. The variable with a significant error correction coefficient would move in the current period to disequilibrium error from the last period. We estimate the above system of equations using OLS because they have same set of explanatory variables which establishes the equivalence between OLS and SUR. As before the above model is estimated separately for each sub-sample and the results are presented in Tables 3 and 4. We find that for both sample periods, the error correction is dominated by durable goods. For example, in the first period both non-durable and durable goods error correct to the long run equilibrium however, the magnitude of adjustment for durable goods (0.094) is more than double of the adjustment in

[19] Note that we are restricting the coefficient of durable goods stock to -1 in the cointegrating vector implied by equation (6).

non-durables (0.039). In the second period, only durable good error corrects towards the long run relationship following a deviation.[20]

5.3 Cyclical Dynamics of Durable Goods

The results presented in the VECM model show that any disequilibrium in the long-run equilibrium relationship between ratio of non-durable and durable goods consumption and relative prices is corrected by the subsequent movements in durable goods consumption. A natural question to ask is what is the consequence of such a change on the cyclical properties of durable goods. In this section we utilize a multivariate extension of the Beveridge-Nelson (BN) (1981) decomposition to identify the permanent and transitory components of the three variables in our cointegrated system. This methodology utilizes the equilibrium correction property and attributes a bigger transitory component to variable(s) that error correct towards the long run equilibrium. In contrast the permanent component dominates the variation in variables that play negligible role in error correction.

According to the Engle-Granger theorem, the BN decomposition of y_t has the following representation:

$$y_t = y_0 + \mu t + \Psi(1) \sum_{k=1}^{t} u_t + \breve{u}_t - \breve{u}_0, \tag{13}$$

where

$$\Psi(1) = \beta_{\perp}(\pi'_{\perp}\Gamma(1)\beta_{\perp})\pi', \tag{14}$$

and $\Psi(L) = \Psi(1)+(1\text{-L})\breve{\Psi}(L)$ and $\breve{u}_t = \breve{\Psi}(L)u_t$. μ is the drift and TS is the stochastic trend. β is the cointegration vector and π is adjustment coefficient vector. The common trend in y_t is extracted using $\text{TS}_t = \Psi(1)\sum_{k=1}^{t} u_t$. $\breve{u}_t - \breve{u}_0$ is the cyclical component. See Favero (2001) for the details on the derivation of the above result.

[20] To take into the short-run outlier effect of COVID on parameter estimates, we perform two exercises. First, we only use data until 2019Q4. In estimate the model until 2019. Second, we estimate the model for the full sample, but include a dummy for the COVID sample period. This dummy is included not only for the intercept, but also interacted with the slope coefficients. Our results for both exercises are qualitatively similar to the ones reported in the paper. For brevity we do not present these results but they are available upon request.

Using this methodology, non-durable consumption, durable goods consumption and relative prices have been decomposed into a BN trend and cycle. Following Morley (2002) we cast the underlying VECM from the previous section into state space format and estimate the model (see Appendix B). We estimate these components for both sub-samples identified by our structural break analysis. Figure 2 shows the estimated cyclical components of non-durable goods and durable goods, revealing three main findings. First, the cycles demonstrate that durable goods have a much larger transitory movement component than non-durable goods. Second, the dynamics of the durable goods cycle have changed over time, with the cyclical component becoming much more persistent in the second period. This higher degree of persistence implies that the speed of mean reversion to the trend has become lower. Third, the estimated durable goods cycle aligns well with the boom and bust of the U.S. business cycles and consistently matches the recession dates. Of particular note is the estimate of the cycle during the pandemic, which suggests that durable goods consumption was at an historic high relative to its trend. According to our estimates, the cyclical component was 24 percent above its long-run trend, as measured by its long-run relationship with non-durable consumption and relative prices. This deviation from its long-run trend was much higher in absolute value than other recessions in the U.S. For example, during the financial crisis of 2008, durable goods spending was roughly 8 percent below its long run common trend as per our estimated model.

An important contribution of our paper is to provide new insights on the dynamics of durable goods spending during the pandemic. The historically high deviation from the common trend that we observe in durable goods spending effectively reflects dramatic changes in the consumption pattern of US households during this period. As the pandemic progressed, an important policy measure was to provide economic stimulus to businesses as well as households. This in part allowed households to finance various adjustments necessitated by the pandemic related changes in work, education, leisure etc. For example, to accommodate online education and remote work, many households undertook home improvements and purchased durable goods such as electronics (e.g., laptops, tablets) and gym equipment.

Another possible pathway for disproportionately tilting household expenditure in favor of durable goods was a sharp reduction in services consumption due to greater risk of exposure. Some analysts suggested that this shift in consumption may be more permanent.[21]. The results presented in our paper suggests that a large portion of this deviation is temporary and there will be a rebalancing in the relative share of the durable goods in the consumption basket. However, the changing cyclical dynamics of durable goods documented in Section 5.3 indicates that the speed of adjustment towards long run equilibrium would be slow. To further explore this implication of our analysis, in the next section we present the dynamic response of durable goods spending to a shock in the disequilibrium error using the local projections framework (Jorda (2005)).

5.4 A Local Projection Approach to Estimate the Dynamics of Adjustment

One of the key findings of the paper, as discussed in the previous section, is that there has been a structural change in the long-run relationship and short-run cyclical dynamics. This was confirmed by analyzing the behavior of the cyclical component of durable goods consumption using multivariate BN decomposition. The changes in the cyclical dynamics suggest that the speed at which durable goods consumption returns to its shared long-run value has changed over time. To investigate whether the speed of convergence has changed in two different samples, one approach is to examine the response of durable goods consumption to a unit shock in disequilibrium error over various forecast horizons. The local projections framework of Jorda (2005) can be used to accomplish this, which traces the dynamic response of durable and non-durable consumption growth over different forecast horizons to a unit shock in the disequilibrium error. We specify the following model:

[21] For example, in a report on consumer spending during the COVID, Deloitte suggested that durable goods spending may remain strong through 2025. See: https://www2.deloitte.com/us/en/insights/economy/us-consumer-spending-after-covid.html

$$\triangle d_{t+k} = \gamma_{10}^k + \sum_{j=1}^{p} \gamma_{11,j}^k \triangle c_{t-j} + \sum_{j=1}^{p} \gamma_{12,j}^k \triangle d_{t-j} + \sum_{j=1}^{p} \gamma_{13,j}^k \triangle p_{t-j} + \beta_h error_{t-1} + u_{dt}$$

where superscript k refers to the time horizon. Number of lags p is chosen by the model selection criteria BIC. Figure 3 (c) and 3 (d) show the response of durable goods consumption growth over different time horizons to a unit change in the deviation from its long-run equilibrium with non-durable consumption and relative prices. To take into account for the structural break, the results are shown separately for the two regimes: 1959Q1-1981Q4 and 1982Q1-2021Q4. The point estimates are plotted along with 90% confidence band compute using Newey-West HAC standard errors. We find that the speed of error correction has slowed down for durable goods with important differences in the dynamics between two subsamples. For example, in the first regime durable good response to an equilibrium deviation was rapid peaking around 6th quarter and converging back to the baseline by 14th quarter. In contrast, in the second regime, the response peaked at 16th quarter and did not become insignificant even at 24 quarters. For non-durable goods, we find significant but short lived response in the first period, and insignificant response at all horizons in the second sample period. These results at further credence to our earlier findings that the nature of adjustment of durable goods to a disequilibrium in the long run relationship with non-durables and relative prices has changed. In recent periods it takes much longer for any shock to error correct mainly because the adjustment of durable goods has slowed significantly.

6 Consumption Cycles and Global Supply Chain Pressure

The pandemic period saw a sustained increase in demand for consumer durables compared to non-durables. Our analysis shows that durable goods were more than 20 percent above the common trend shared by durables, non-durables, and relative prices. The production of durable goods involves intricate global value chains that outsource various stages of the production process. While these global value chains enable companies to specialize, they also expose them to risks arising from fluctuations in domestic and foreign markets. The COVID-19 pandemic created unprecedented challenges as governments worldwide implemented containment measures that strained supply chains and shipping networks while also leading to a sharp rise in demand for durable goods. The extraordinary pressure on the global supply chain in recent years was attributed to the unprecedented rise in durable goods spending in popular and business media. The increase in inflation during this period was also attributed to the global supply chain pressure (LaBelle and Santacreu, 2022).[22]

In this section, we provide a systematic analysis of the link between the durable good cycle, which we interpret as a measure of excess demand, and the global supply chain pressure.[23] We use the Global Supply Chain Pressure Index (GSCPI) developed by the Federal Reserve Bank of New York to capture supply chain pressure. Note that this data is only available starting 1998Q1 and as a result our analysis in this section focuses on the estimated durable gods cycle for the second sub-sample. We first examine whether past movements in the durable goods cycle affect the GSCPI index. From Table 5 we find no evidence for such a relationship, even after control for the pandemic era using an indicator value that takes value of 1 beginning in 2020:Q1.

It is possible that the relationship between durable goods cycle and the GSCPI is non-linear wherein only during periods of very high cyclical fluctuations do we see an increase in the supply chain pressure. To test for this possibility we first estimate a threshold regression model. Such models allow for capturing a regime switch in the relationship of interest and are commonly utilized in the literature on non-linear time series.[24] We estimate a threshold model with multiple endogenously determined regimes, and we determine the number of regimes using the Bai and Perron (1998) tests of $L + 1$ versus L sequentially determined

[22]It is important to note that the latest information regarding the stress on the supply chain shows a notable reduction. This reduction aligns with a decrease in the inflationary pressure experienced in the goods industries.

[23]Note that services, that are mostly nontradable, form a large part of non-durable consumption. As a result it is less likely that cyclical fluctuations in non-durable consumption have a large effect on global supply chains. We did estimate the relationship between GSCPI and non-durable goods cycle and found no evidence of a relationship, linear or non-linear. For brevity these results are not reported in the paper but are available upon request.

[24]See Hansen (2000, 2011) for details on Threshold Regression Models.

thresholds. The results are presented in Table 6. The estimated threshold value for the standardized durable goods cycle is 0.732 which is roughly 82nd percentile. Regime 1 in Table 5 is when durable goods cycle is below this threshold and Regime 2 is above the threshold. We find that in Regime 1 the relationship between durable goods cycle and the GSCPI is weakly negative and statistically insignificant. In contrast, in Regime 2, a one standard deviation increase in durable goods cycle increases the GSCPI by 1.6 standard deviations and this effect is statistically significant.

One concern with the results presented in Table 6 is that the estimation is not robust to large outliers in the data. The GSCPI data had a substantial spike in the data during the pandemic and to address this concern, in Table 7 we present robust regression results using the Huber Loss function in place of the least squares objective function. We also use the 75th percentile of the standardized durable good cycle to distinguish between large and small cyclical fluctuations. Again, we find that the effect of large durable goods cycles is positive and statistically significant. For example, from Table 8 we find that when durable goods cycle exceeds its 75th percentile, one standard deviation increase in this cycle increases the GSCPI by 0.962 standard deviation. These findings confirm the anecdotal reporting during the pandemic about the association between an unprecedented increase in consumer durable demand and pressure on the global supply chain.

7 Conclusion

Can we use the relationship between the ratio of durable goods consumption to non-durable goods consumption and their relative prices to quantify the deviation of durable goods consumption from its long-term trend? Has the relationship between the ratio of durable goods consumption to non-durable goods consumption and relative prices changed in the U.S. due to structural changes in the economy? The answer to both questions is yes. We utilize the modified intertemporal model that includes consumer durables, a la Ogaki and Reinhart (1998), to estimate the long-run relationship between durables-non-durables consumption ratio and relative prices. The coefficient on relative prices is interpreted as the intratemporal elasticity of substitution between durables and nondurables. We find a structural change in the long-term relationship in 1981Q4, which resulted in a decrease in the intratemporal elasticity of substitution during the later part of the sample period. We use the long-run equilibrium relationship to estimate cycles - the deviation of durable and nondurable consumption from its long-run trend for both sample periods. Our results show that there has been a significant change in the dynamics of consumption cycles. We find that the durable goods consumption cycle is much larger than the nondurable goods cycle. This is not surprising since any disequilibrium in the long-run relationship is corrected by subsequent movements in durable goods consumption. One of the important implications of the structural break in the relationship is that the cyclical dynamics of durable goods consumption have changed in the recent period with a higher degree of persistence. This suggests that the rate of return to the trend of durable goods consumption is slower in the recent period compared to the earlier sample. Our results also have implications for the dramatic changes in consumption patterns in the COVID period. Our model shows that durable goods consumption was more than 20 percent above its long-run value at the height of the pandemic. The higher persistence of the durable goods cycle in the recent time period also implies that it will take longer for durable goods consumption to revert back to its long-run trend.

References

[1] Ando, A., & Modigliani, F. (1963). The life cycle hypothesis of saving: Aggregate implications and tests. The American economic review, 53(1), 55-84.

[2] Arai, Y., & Kurozumi, E. (2007). Testing for the null hypothesis of cointegration with a structural break. Econometric Reviews, 26(6), 705-739.

[3] Atkeson, A., & Ogaki, M. (1996). Wealth-varying intertemporal elasticities of substitution: Evidence from panel and aggregate data. Journal of monetary Economics, 38(3), 507-534.

[4] Bai, J., & Perron, P. (1998). Estimating and testing linear models with multiple structural changes. Econometrica, 47-78.

[5] Bernanke, Ben (2003), "'Constrained Discretion,' and Monetary Policy," Remarks Before the Money Marketeers of New York University, New York, New York, February 3, 2003.

[6] Beveridge, S., & Nelson, C. R. (1981). A new approach to decomposition of economic time series into permanent and transitory components with particular attention to measurement of the 'business cycle'. Journal of Monetary economics, 7(2), 151-174.

[7] Bhatt, V., Kundan Kishor, N., & Marfatia, H. (2020). Estimating Excess Sensitivity and Habit Persistence in Consumption Using Greenbook Forecasts. Oxford Bulletin of Economics and Statistics, 82(2), 257-284.

[8] Dynan, K. E., Elmendorf, D. W., & Sichel, D. E. (2006). Can financial innovation help to explain the reduced volatility of economic activity?. Journal of monetary Economics, 53(1), 123-150.

[9] Engle, Robert and Clive W.J. Granger (1987). "Cointegration and Error Correction: Representation, Estimation and Testing." Econometrica, 55(2): 251-275.

[10] Favero, C. A. (2001). Applied macroeconometrics. Oxford University Press.

[11] Friedman, M. (1957). The permanent income hypothesis. In A theory of the consumption function (pp. 20-37). Princeton University Press.

[12] Hall, R. E. (1978). Stochastic implications of the life cycle-permanent income hypothesis: theory and evidence. Journal of political economy, 86(6), 971-987.

[13] Hall, R. E. (1988). Intertemporal substitution in consumption. Journal of political economy, 96(2), 339-357.

[14] Hall, R. E. (2011). The long slump. American Economic Review, 101(2), 431-69.

[15] Hansen, B. E. (2000). Sample splitting and threshold estimation. Econometrica, 68(3), 575-603.

[16] Hansen, B. E. (2011). Threshold autoregression in economics. Statistics and its Interface, 4(2), 123-127.

[17] Hansen, L. P., & Singleton, K. J. (1996). Efficient estimation of linear asset-pricing models with moving average errors. Journal of Business & Economic Statistics, 14(1), 53-68.

[18] Hymans, S. H., Ackley, G., & Juster, F. T. (1970). Consumer durable spending: explanation and prediction. Brookings Papers on Economic Activity, 1970(2), 173-206.

[19] Kejriwal, M. (2008). Cointegration with structural breaks: An application to the Feldstein-Horioka puzzle. Studies in nonlinear dynamics & econometrics, 12(1).

[20] Kejriwal, M., & Perron, P. (2010). Testing for multiple structural changes in cointegrated regression models. Journal of Business & Economic Statistics, 28(4), 503-522.

[21] Kim, C. J., & Nelson, C. R. (1999). Has the US economy become more stable? A Bayesian approach based on a Markov-switching model of the business cycle. Review of Economics and Statistics, 81(4), 608-616.

[22] LaBelle, J., & Santacreu, A. M. (2022). Global supply chain disruptions and inflation during the COVID-19 pandemic. Federal Reserve Bank of St. Louis Review.

[23] Leamer, E. E. (2007). Housing is the business cycle. NBER Working Paper.

[24] Leamer, E. E. (2009). Homes and cars: Why are the cycles in homes and consumer durables so similar?. The BE Journal of Economic Analysis & Policy, 9(3).

[25] Levy, D. and Chen, H. (1994), Estimates of the aggregate quarterly capital stock for the post-war U.S. economy. Review of Income and Wealth, 40: 317-349.

[26] Mankiw, N. G. (1982). Hall's consumption hypothesis and durable goods. Journal of Monetary Economics, 10(3), 417-425.

[27] McConnell, M. M., & Perez-Quiros, G. (2000). Output fluctuations in the United States: What has changed since the early 1980's?. American Economic Review, 90(5), 1464-1476.

[28] McKay, A., & Wieland, J. F. (2021). Lumpy durable consumption demand and the limited ammunition of monetary policy. Econometrica, 89(6), 2717-2749.

[29] Morley, J. C. (2002). A state–space approach to calculating the Beveridge–Nelson decomposition. Economics Letters, 75(1), 123-127.

[30] Ogaki, M., & Reinhart, C. M. (1998). Measuring intertemporal substitution: The role of durable goods. Journal of political Economy, 106(5), 1078-1098.

[31] Okubo, M. (2003). Intratemporal substitution between private and government consumption: the case of Japan. Economics Letters, 79(1), 75-81.

[32] Okubo, M. (2008). On the intertemporal elasticity of substitution under nonhomothetic utility. Journal of Money, Credit and Banking, 40(5), 1065-1072.

[33] Pakoš, M. (2011). Estimating intertemporal and intratemporal substitutions when both income and substitution effects are present: the role of durable goods. Journal of Business & Economic Statistics, 29(3), 439-454.

[34] Power, J. (2004). Durable spending, relative prices and consumption. Bank of England Quarterly Bulletin, Spring.

[35] Startz, R. (1989). The stochastic behavior of durable and nondurable consumption. The Review of Economics and Statistics, 356-363.

[36] Van Zandweghe, W., & Braxton, J. C. (2013). Has durable goods spending become less sensitive to interest rates?. Economic Review-Federal Reserve Bank of Kansas City, 5.

A Appendix A: Construction of Quarterly Durable Goods Stock

In this section we provide a detailed account of the computation of the real durable goods stock. The methodology follows Levy and Chen (1994) and has been utilized extensively in the literature on durable goods consumption. Let E_{qt} and D_{qt} denote real personal expenditure and real stock of durable goods for quarter q at time t. δ_t denotes depreciation rate of quarter q for year t. Then, for any given quarter we have the following relationship between quarterly expenditure flows and stock:

$$D_{qt} = (1 - \delta_t) \cdot D_{q-1t} + E_{qt}$$

In order to obtain a quarterly series for durable good stock we use the last year's real annual durable stock data from NIPA to estimate δ_q in the above equation so that for every year, the last quarter value matches the year end value exactly. Formally, let D_{t-1} denotes real annual durable good stock at time $t-1$. Then, for any given year t we get following four equations, one for each quarter:

$$D_{1t} = (1 - \delta_t) \cdot D_{t-1} + E_{1t} \tag{A1}$$

$$D_{2t} = (1 - \delta_t) \cdot D_{1t} + E_{2t} \tag{A2}$$

$$D_{3t} = (1 - \delta_t) \cdot D_{2t} + E_{3t} \tag{A3}$$

$$D_{4t} = (1 - \delta_t) \cdot D_{3t} + E_{4t} \tag{A4}$$

Using successive iteration and noting that for matching the year end annual stock we impose $D_{4t} = D_t$ we get the following non-linear equation in δ_t:

$$D_t = (1 - \delta_t)^4 \cdot D_{t-1} + (1 - \delta_t)^3 \cdot E_{1t} + (1 - \delta_t)^2 \cdot E_{2t} + (1 - \delta_t) \cdot E_{3t} + E_{4t}$$

We solve the above equation for δ_t. Once we have the estimated depreciation rate we use equations (A1)-(A4) recursively to compute the quarterly time series of durable goods stock.

B State Space Representation of the VECM Model

The state space representation of the VECM model is based on Morley (2002).

Measurement equation:

$$\begin{bmatrix} \triangle c_t \\ \triangle d_t \\ \triangle p_t \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} \triangle c_t \\ \triangle d_t \\ \triangle p_t \\ \triangle c_t - \triangle d_t - \beta \triangle p_t \end{bmatrix} \tag{B1}$$

Transition equation is:

$$\begin{bmatrix} \triangle c_t \\ \triangle d_t \\ \triangle p_t \\ \triangle c_t - \triangle d_t - \beta \triangle p_t \end{bmatrix} = \begin{bmatrix} \phi_{11} & \phi_{12} & \phi_{13} & \pi_c \\ \phi_{21} & \phi_{22} & \phi_{23} & \pi_d \\ \phi_{31} & \phi_{32} & \phi_{33} & \pi_p \\ \phi_{11} - \phi_{21} - \beta\phi_{31} & \phi_{12} - \phi_{22} - \beta\phi_{32} & \phi_{13} - \phi_{23} - \beta\phi_{33} & 1 + \pi_c - \pi_d - \beta\pi_p \end{bmatrix}$$
$$\times \begin{bmatrix} \triangle c_{t-1} \\ \triangle d_{t-1} \\ \triangle p_{t-1} \\ \triangle c_{t-1} - \triangle d_{t-1} - \beta \triangle p_{t-1} \end{bmatrix} + \begin{bmatrix} u_{ct} \\ u_{dt} \\ u_{pt} \\ u_{ct} - u_{dt} - \beta u_{pt} \end{bmatrix}$$

Note that $\triangle c_t = c_t - c_{t-1}$.We can use $\triangle c_t - \triangle d_t - \beta \triangle p_t$ to get the above representation.

Table 1: Test of cointegration with breaks

	Test-statistic	5% Critical Values
AK test	0.057	0.15
UD-max	67.26	12.25
No. of Breaks and date	1	1981Q4

Table 2: Estimation Results for Cointegrating Relationship

Regime	Dates	$\widehat{\alpha}$	$\widehat{\gamma}$
1	1959Q1-1981Q4	0.313	1.123
		(0.053)	(0.0439)
2	1982Q1-2021Q4	0.731	0.763
		(0.008)	(0.0137)

Table 3: Vector Error Correction Model Estimates: Regime 1

Explanatory Variables	$\triangle c_t$	$\triangle d_t$	$\triangle p_t$
$\triangle c_{t-1}$	0.290**	0.512**	-0.202
	(0.11)	(*0173*)	(0.12)
$\triangle d_{t-1}$	-0.053	0.302**	0.065
	(0.058)	(0.09)	(0.064)
$\triangle p_{t-1}$	0.144	-0.402**	0.562**
	(0.10)	(0.158)	(0.11)
$\beta' z_{t-1}$	0.039**	0.094**	-0.002
	(0.02)	(0.036)	(0.025)

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

(i) Newey-West Standard Errors are in parentheses.
(ii) $\triangle c_t$ is rate of growth of non-durable consumption, $\triangle d_t$, is rate of growth of durable consumption flow, $\triangle p_t$ is rate of growth of relative price, and $\beta' z_{t-1}$ is disequilibrium from the last period.

Table 4: Vector Error Correction Model Estimates: Regime 2

Explanatory Variables	$\triangle c_t$	$\triangle d_t$	$\triangle p_t$
$\triangle c_{t-1}$	0.423**	0.308**	-0.034
	(0.07)	(0.15)	(0.112)
$\triangle d_{t-1}$	0.056	0.410**	-0.061
	(0.038)	(0.076)	(0.054)
$\triangle p_{t-1}$	0.059	-0.068	0.467**
	(0.054)	(0.107)	(0.077)
$\beta' z_{t-1}$	0.017	0.042**	-0.005
	(0.018)	(0.018)	(0.013)

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

(i) Newey-West Standard Errors are in parentheses.
(ii) $\triangle c_t$ is rate of growth of non-durable consumption, $\triangle d_t$, is rate of growth of durable consumption flow, $\triangle p_t$ is rate of growth of relative price, and $\beta' z_{t-1}$ is disequilibrium from the last period.

Table 5: Relationship between Supply Chain Pressure and Durable Goods Cycles

Dependent Variable: GSCPI_t	
$Dummy$	1.372
	(0.00)
GSCPI_{t-1}	0.622
	(0.00)
BND_{t-1}	-0.016
	(0.82)
$\text{GSCPI}_{t-1} * Dummy$	-0.064
	(0.795)
$BND_{t-1} * Dummy$	0.134
	(0.489)

Table 6: Results of the Threshold Regression Model

	Dependent Variable: GSCPI	
	Regime 1 (Below Threshold)	*Regime 2 (Above Threshold)*
BND_{t-1}	-0.008	1.617***
	(0.082)	(0.261)
$GSCPI_{t-1}$	0.892***	0.166
	(0.099)	(0.153)
	0.023	-1.782***
	(0.067)	(0.32)
Observations	79	16
R-squared	0.799	

$^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

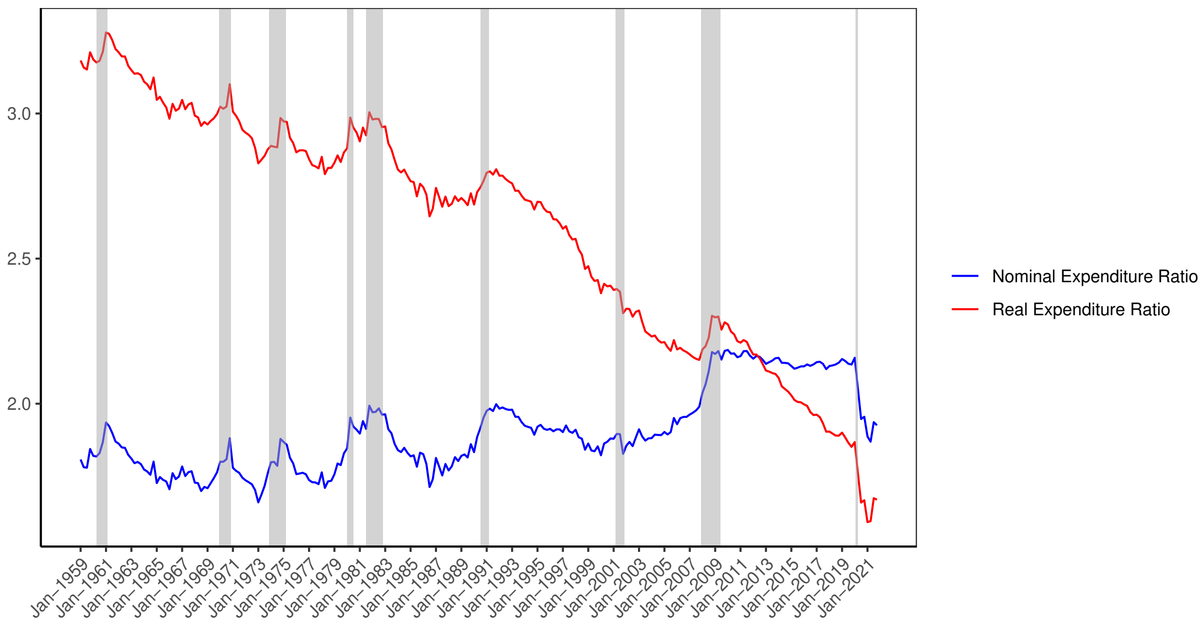
Table 7: Results of Robust Regression

	Dependent Variable: GSCPI
BND_{t-1}	0.0309
	(0.0978)
$I(Cycle >= p75)$	-0.792***
	(0.200)
$I(Cycle >= p75) \times BND_{t-1}$	0.962***
	(0.191)
$GSCPI_{t-1}$	0.609***
	(0.0779)
Constant	-0.0489
	(0.0694)
Observations	95

Standard errors in parentheses

$^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

(a) Nominal and Real Expenditure Ratios



(b) Real Expenditure Ratio and Relative Price

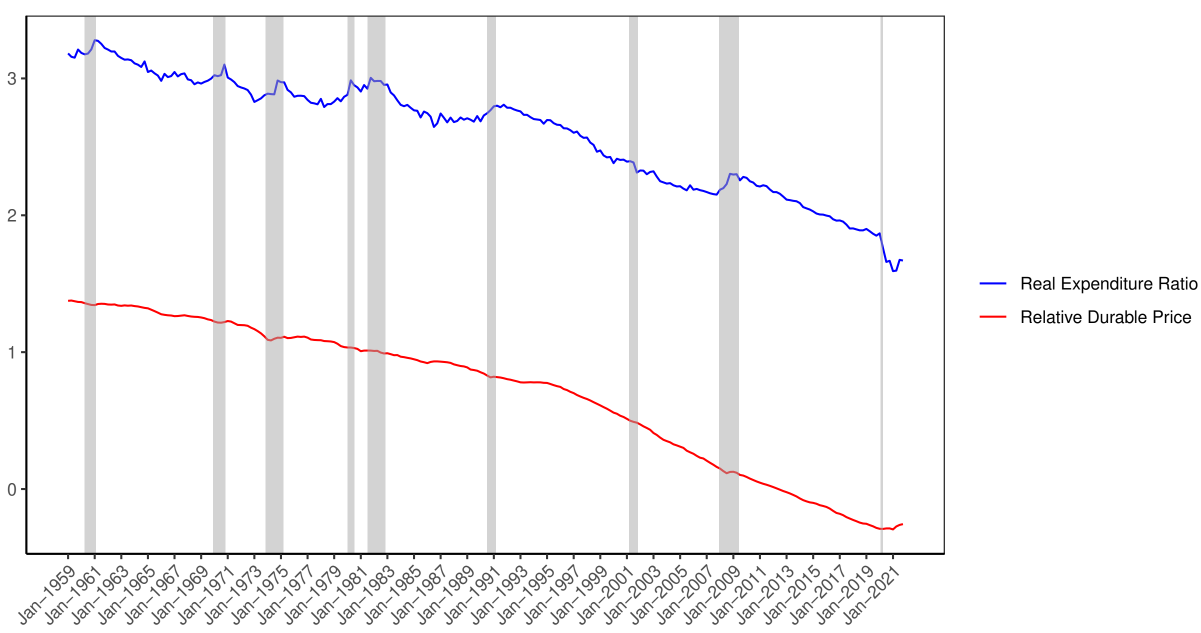
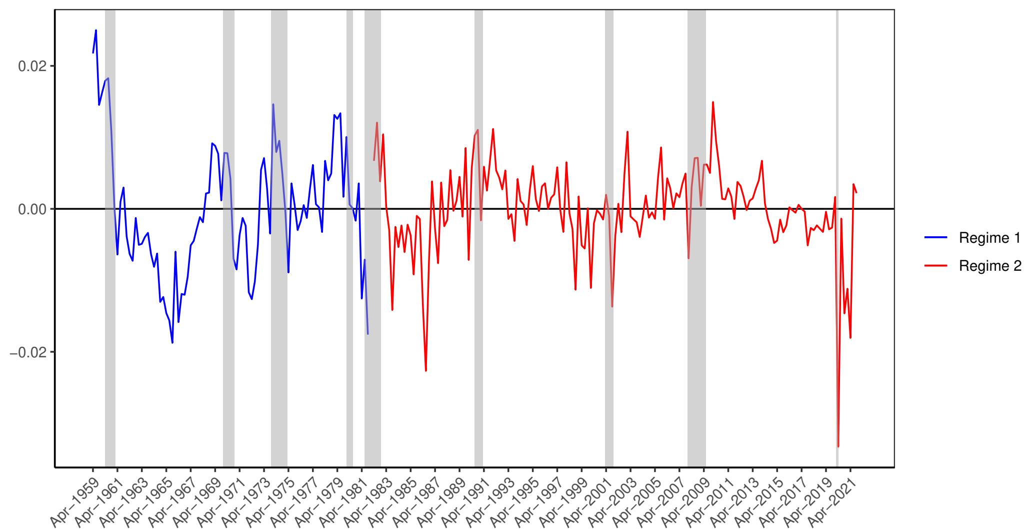


Figure 1: Evolution of relative expenditure and prices (in natural logs)

(a) Non-durable Goods Cycle



(b) Durable Goods Cycle

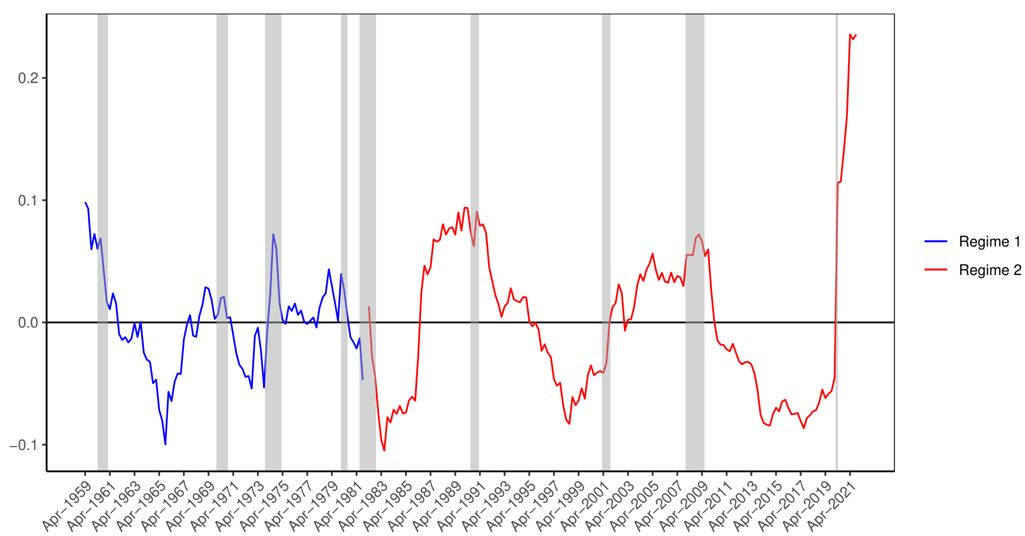
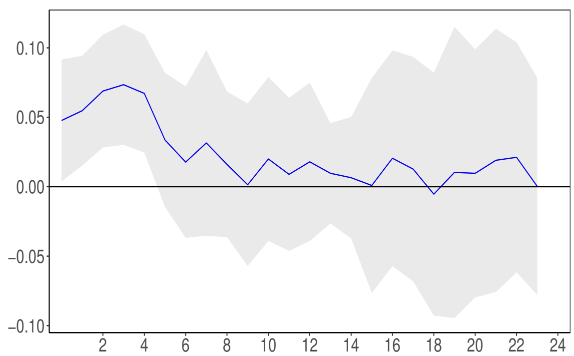
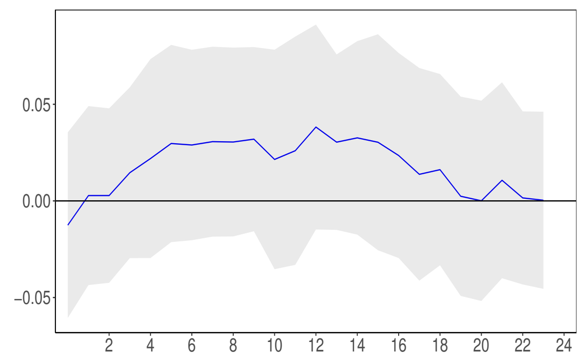


Figure 2: Cyclical Component from Multivariate BN Decomposition

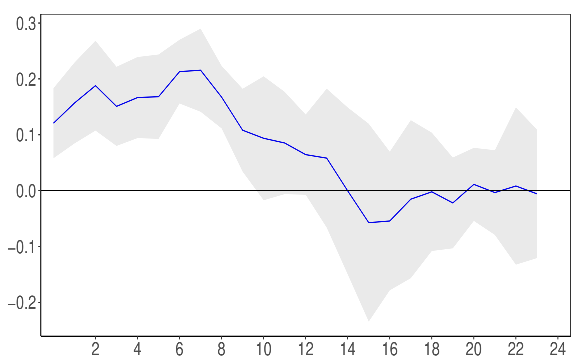
(a) Non-durable Goods: Regime 1



(b) Non-durable Goods: Regime 2



(c) Durable Goods: Regime 1



(d) Durable Goods: Regime 2

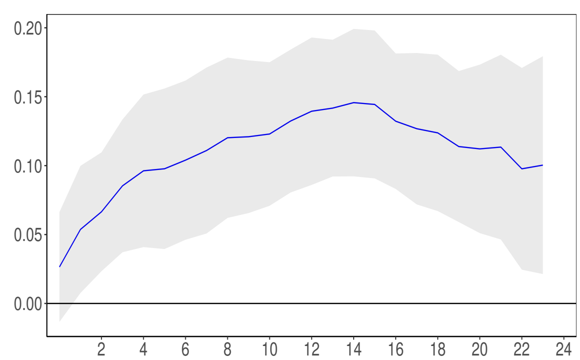


Figure 3: Local Projections Based IRF