

# NOTES ON THE THEORY AND EVIDENCE ON AGGREGATE PURCHASES OF DURABLE GOODS

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## I. INTRODUCTION

More than 15 years ago Robert Hall (1978) demonstrated that under the basic permanent income hypothesis model (PIH), non-durable consumption growth should be unpredictable.<sup>2</sup> Researchers now seem to agree that this elegant implication of the PIH does not hold in the data, regardless of the country and sample used. But it almost holds! Indeed, post-war US quarterly non-durable consumption growth is very close to white noise. This marginal rejection becomes easier to identify once researchers provide structural interpretations to

predicted consumption growth, such as liquidity constraints, or look at microeconomic data.

If one tests the same theory using data on aggregate *durable* expenditures, however, there is no place for ambiguity. By Hall's insight, the rate of growth of the *stock* of durables should also be unpredictable white noise.<sup>3</sup> However, the quarterly rate of growth of the post-war US stock of durables has strong positive serial correlation. The rejection of the basic theory for durable goods is an order of magnitude larger than for non-durables. As I will document below, this is true for total durable ex-

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<sup>2</sup> Of course this requires additional assumptions on preferences and asset returns. In these notes I will highlight only those elements which are important for an overall assessment while keeping in the background secondary assumptions whose only role is to tighten the arguments.

<sup>3</sup> This requires the additional assumption that services from durables be proportional to the stock of durables.

penditures as well as across different categories of durable goods. I find it somewhat paradoxical that so much effort during the 1980s—perhaps more than in any other topic in macroeconomics—was devoted to explaining the ‘small’ rejection and so little to explaining the ‘large’ one.

An alternative demonstration of the inadequacy of the basic theory can be expressed in terms of the properties of the flow of expenditure on durable goods. This is the avenue followed by Mankiw (1982). Combining the white-noise implication for the rate of growth of the stock with the perpetual inventory formula for new stock accumulation yields a simple first-order moving average (MA(1)) expression for *expenditure* growth.<sup>4</sup> Since durables last for more than one period, an initial increase in expenditure to set the stock at a new higher level does not require subsequent expenditures, except for depreciation. This implies that the moving average coefficient for expenditure growth should be negative and equal (in absolute value) to one minus the depreciation rate, or about  $-0.95$  in quarterly data. Mankiw (1982) found a strong rejection of this prediction of the basic theory in US post-war quarterly data. The estimated MA coefficient is approximately zero, implying that the growth in expenditure on durables is well characterized by a white-noise process.

In Caballero (1990) I qualified Mankiw’s finding. The negative correlation that the basic PIH predicts in the rate of growth of expenditure on durables does not vanish, but it is delayed by several quarters. This finding does not save the frictionless PIH model, but it suggests that an amended version, with significant adjustment costs, has the potential to explain the facts.

Macroeconomists have typically handled sluggish aggregate dynamics by postulating the existence of convex—usually quadratic—adjustment costs within the context of a representative agent model. This is largely counterfactual at the microeconomic level, where purchases of durable goods are sporadic and lumpy rather than continuous and smooth.

These notes focus on work that has explicitly modelled the lumpy and intermittent nature of microeconomic adjustment and the implications for aggregate expenditure on durable goods.

Lumpy and intermittent adjustment of the stock of durables at the microeconomic level can arise from the presence of fixed costs of adjustment. There are many potential sources of fixed costs, including taxes and other transactions costs, time spent searching among heterogeneous products, and imperfections in the secondary market owing to ‘lemons’ problems. These costs generate microeconomic policies which exhibit a range of inaction where individual units passively tolerate ‘small’ departures from some ever-changing frictionless optimum level of the stock. Once the departures reach critical thresholds, the consumer abruptly buys or sells to reduce the disequilibrium. Microeconomic policies with such strong non-linear adjustment policies are often described as  $(S,s)$  rules. I will devote a section of this paper to characterizing these rules.

Unlike microeconomic series, aggregate series are smooth and continuous. In order to transform the  $(S,s)$  model into a theory that can explain the aggregate facts which motivate these notes, heterogeneity must be introduced to eliminate the synchronization of individual agents. While heterogeneity makes the theory somewhat more complex, it adds an important element of realism which is not present in representative agent models.

In the notes that follow, I will expand and fill in the missing pieces of the previous discussion. In the next section I briefly review the basic PIH model for durable goods and present evidence on the inadequacy of this model to characterize data on aggregate expenditure on durables. Section III describes the basic microeconomic features of  $(S,s)$  models. Section IV sketches results on the dynamic aggregation of these microeconomic policies and summarizes recent empirical evidence supporting these models. Section V concludes.

<sup>4</sup> Strictly speaking, all the derivations implicit in my description apply to the changes in the (possibly detrended) levels rather than to the rates of growth. This distinction, however, does not affect the basic time-series properties that I emphasize in these notes. I adopt the rate of growth specification because this simplifies detrending and heteroskedasticity corrections.

**Table 1**  
**Moving Average for Expenditure Growth**

	Total	Automobiles	Furniture
MA(1)	-0.075 (0.074)	-0.123 (0.074)	-0.287 (0.071)
DW	2.014	2.008	2.139
Q(39)	39.88	47.60	42.85

*Notes:* Sample: 1947:2–1993:1. Standard errors in parentheses. DW: Durbin–Watson. Q(39): q-statistic with 39 degrees of freedom.

## II. THE BASIC PIH MODEL AND AGGREGATE TIME-SERIES EVIDENCE

The principal insight of Hall's (1978) result is that individuals, including the representative agent, smooth consumption over time. Therefore, abrupt changes in the marginal utility of consumption must be brought about by surprises in permanent income.<sup>5</sup> With a few auxiliary assumptions (including separability across goods and time), this result can be extended to the services provided by durable goods. That is, removing trends and assuming services are proportional to the stocks:

$$\Delta K_t = \varepsilon_t, \quad E_{t-1}[\varepsilon_t] = 0, \quad (1)$$

with  $K$  the aggregate stock of durables and  $E_t$  the expectation operator conditional on information available at time  $t$ . Further, assuming the stock of durables depreciates geometrically at the rate  $\delta$ , and taking first differences, implies:

$$\Delta K_t = (1 - \delta) \Delta K_{t-1} + \Delta CD_t, \quad (2)$$

where  $CD_t$  is expenditure on durables. Replacing (1) in (2), yields the MA(1) for changes in expenditure on durables:

$$\Delta E_t = \varepsilon_t - (1 - \delta)\varepsilon_{t-1}. \quad (3)$$

This expression converges to the standard white-noise result for non-durables as  $\delta$  tends to one.

Table 1 shows estimates of equation (3) for quarterly expenditure on different categories of US durables from 1947:2 to 1993:1.<sup>6</sup> The first column gives results for total durables, the second for automobiles, and the last for furniture. In all cases, the MA coefficient is significantly different from  $-(1 - \delta)$ , strongly rejecting the basic PIH, and confirming the findings in Mankiw (1982). The growth rate in durable expenditures appears to be white noise.

Another way to assess the magnitude of the rejection is by noticing that if preference and relative price shocks are not important relative to permanent income shocks,  $\Delta C_t$  is approximately proportional to  $\varepsilon_t$ , where  $C_t$  is expenditure on non-durables. Thus, a modified equation (3) is:

$$\Delta CD_t = \alpha \Delta C_t - \alpha(1 - \delta) \Delta C_{t-1} + e_t, \quad (4)$$

where  $\alpha$  is a proportionality factor and  $e_t$  captures distributional shocks across different categories of goods.<sup>7</sup> Under the simple PIH, the ratio of the two estimated coefficients in (4) should equal  $-(1 - \delta)$ . Table 2 shows estimates of equation (4) using the same categories of durables. Once again it is clear that the lagged coefficient is approximately zero and that the ratio condition does not hold.

<sup>5</sup> For simplicity, I will not discuss shocks to preferences.

<sup>6</sup> The regressions are in logarithms with a constant.

<sup>7</sup> These shocks must have small effects on non-durables to avoid simultaneity problems. See Caballero (1990) for empirical evidence supporting this view.

**Table 2**  
**Regressions on Non-durables**

	Total	Automobiles	Furniture
Ratio of coefficients*	0.037 (0.192)	0.084 (0.317)	-0.123 (0.159)
DW	2.192	2.308	2.632
Q(39)	51.30	65.57	46.99

*Notes:* \* Coefficients on lagged non-durables growth over contemporaneous non-durables growth. Sample: 1947:2–1993:1. Standard errors in parentheses. DW: Durbin–Watson. Q(39): q-statistic with 39 degrees of freedom.

Suppose now that the aggregate stock of durables adjusts slowly to innovations. For example, let  $\Delta K_t = \alpha \varepsilon_t + (1 - \alpha) \varepsilon_{t-1}$ , with  $0 < \alpha < 1$ .<sup>8</sup> Replacing this new expression into (2) yields:

$$\Delta CD_t = v_t + \left\{ \frac{(1 + \alpha\delta - 2\alpha)}{\alpha} \right\} v_{t-1} - \left\{ \frac{(1 - \alpha)(1 - \delta)}{\alpha} \right\} v_{t-2}, \quad (5)$$

where  $v_t \equiv \alpha \varepsilon_t$ . The most interesting aspect of this equation is that if  $\alpha$  is sufficiently less than one, the first moving average coefficient can be very close to zero. Also note that the sum of moving average coefficients is  $-(1 - \delta/\alpha)$ . Thus, if  $\alpha \gg \delta$ , which is likely for reasonable adjustment costs, the large negative MA(1) term of the frictionless model is spread out over several moving average terms, but it is still reflected in the sum of moving average coefficients. This is just an example. In Caballero (1990) I studied more general cases and found that in the US the sum of moving average coefficients is about  $-0.9$  after 3 years of delay. In Caballero (1993) I showed that within durables, convergence is faster for automobiles than for furniture. This result is consistent with the fact that adjustment costs are larger in the furniture market than in the automobile market. Table 3 shows the cumulative sum of moving average coefficients and their standard errors for an MA(15), estimated with quarterly data using the same categories as Tables 1 and 2. Once more, the conclusion is strikingly uniform and consistent with the slow adjustment interpretation. All three categories sum to negative numbers which are statistically significant. The adjustment is fastest in the total durables category, followed by

automobiles, and then furniture, although these differences are not statistically significant.

Running the slow adjustment equivalent of equation (4), where permanent income shocks are approximated by changes in non-durables consumption, yields conclusions similar to those in Table 3, although the sums of coefficients are estimated less precisely.

Having characterized the sluggish behaviour of aggregate expenditure on durable goods, I now move on to review and construct a plausible explanation for such behaviour: the presence of fixed costs of adjustment at the microeconomic level.

### III. MICROECONOMIC ADJUSTMENT WITH FIXED COSTS

An individual consumer who behaves according to the frictionless PIH will respond instantaneously to all shocks. As discussed above, aggregating up the behaviour of such consumers would yield implications that are largely inconsistent with the sluggish behaviour of aggregate time series on durable purchases. Sluggishness at the aggregate level may result from the continuous but slow adjustment of individual consumers, or by the intermittent and lumpy adjustment of less than perfectly synchronized consumers.

In the former case, smooth and sluggish microeconomic adjustment emerges naturally from standard

<sup>8</sup> This is just a convenient example of delayed adjustment and inertia in the stock of durable goods. As is, it does not have microfoundations; if needed, the reader may think of this as an approximation of the solution of an autoregressive habit formation model or a quadratic adjustment cost model.

**Table 3**  
**Sum of Moving Average Coefficient or an MA(15) on Expenditure Growth**

Sum of $n$ MA coeff.	Total	Automobiles	Furniture
1	-0.123 (0.077)	-0.162 (0.077)	-0.343 (0.077)
2	-0.040 (0.109)	-0.102 (0.109)	0.014 (0.112)
3	-0.152 (0.133)	-0.143 (0.133)	-0.205 (0.141)
4	-0.217 (0.154)	-0.186 (0.154)	-0.097 (0.165)
5	-0.225 (0.172)	-0.184 (0.172)	-0.076 (0.187)
6	-0.241 (0.189)	-0.093 (0.188)	-0.327 (0.206)
7	-0.328 (0.204)	-0.214 (0.204)	-0.476 (0.224)
8	-0.539 (0.218)	-0.358 (0.218)	-0.394 (0.241)
9	-0.606 (0.231)	-0.443 (0.232)	-0.285 (0.257)
10	-0.589 (0.244)	-0.426 (0.268)	-0.305 (0.270)
11	-0.597 (0.257)	-0.394 (0.257)	-0.242 (0.285)
12	-0.668 (0.269)	-0.429 (0.268)	-0.448 (0.297)
13	-0.654 (0.280)	-0.451 (0.279)	-0.390 (0.309)
14	-0.816 (0.291)	-0.608 (0.290)	-0.470 (0.320)
15	-0.903 (0.301)	-0.674 (0.301)	-0.549 (0.329)
DW	1.992	2.000	1.997
Q(39)	18.61	27.72	9.11

*Notes:* Sample: 1947:2–1993:1. Standard errors in parentheses. DW: Durbin–Watson. Q(39): q-statistic with 39 degrees of freedom.

convex adjustment cost models, the quadratic in particular. Aggregate dynamics in this model follow directly from microeconomic dynamics. Its analytical tractability has made the quadratic-convex adjustment cost model a favourite among macroeconomists. Unfortunately, it is largely inconsistent with the lumpy pattern of microeconomic purchases of durable goods.

Models with non-convex or, in particular, fixed costs of adjustment have the potential to generate realistic behaviour at both the microeconomic and macroeconomic levels. With fixed costs, an individual consumer's durable goods purchases will be lumpy and intermittent, while the aggregate series will adjust sluggishly, if consumers are not perfectly synchronized. The cost of this microeconomic

realism is the additional complexity of solving a non-trivial aggregation problem. I postpone discussion of the aggregation problem until the next section, while in this one I provide an heuristic description of individuals' optimal adjustment pattern when facing fixed costs of adjustment.

By what fraction of a new shock do consumers adjust their stock of durables? Given quadratic adjustment costs, the answer is straightforward: a time-invariant fraction of the shock equal to the standard partial adjustment coefficient. If there are fixed costs of adjustment, however, the answer is more complicated. To see this, consider the situation where before the shock the consumers are holding their desired stock of durables. Then the answer to the previous question must depend on the size of the shock. If the shock is small relative to the fixed cost of adjustment, they will not adjust at all. But if the shock is large relative to the adjustment cost, they will adjust fully.<sup>9</sup> This simple description begins uncovering the very non-linear nature of the resulting microeconomic policies.

Another source of complexity in fixed-cost models is the strong history-dependence of adjustment policies. In quadratic adjustment cost models, agents adjust by a time-invariant fraction of new shocks. In non-convex adjustment cost models, however, the amount of new purchases depends on the entire past history of shocks. To see this, imagine that the previous shock was small, so that there was no adjustment, and that a new shock hits the consumer. How much will the consumer adjust? The answer clearly depends on whether the new shock is in the same direction as the previous shock or not. In other words, the relative size of a given shock and any resulting adjustment depends on the *accumulation* of shocks since the last time the consumer adjusted.

There is an extensive literature characterizing microeconomic adjustment in the presence of fixed costs of adjustment (see e.g. Harrison *et al.*, 1983; Bertola and Caballero, 1990; Grossman and Laroque, 1990;

Dixit, 1991; Beaulieu, 1993). Although the mathematical obstacles of particular applications can be cumbersome, the common essence of the solutions is not. Define a disequilibrium variable  $z$  to be equal to the difference between a consumer's actual stock of durables,  $k$ , and the amount he or she would hold if adjustment costs were momentarily removed,  $k^*$ :<sup>10</sup>

$$z_t \equiv k_t - k_t^*$$

Figure 1(a) illustrates a possible path of  $z$  with positive depreciation, panel (b) shows the corresponding adjustment of stocks, and panel (c) shows the path of expenditure.

This policy can be characterized by three numbers,  $(L, C, U)$ , representing the lower trigger, the centre or return point, and the upper trigger. It is sometimes referred to as a two-sided  $(S, s)$  policy. Whether the model is two-sided or one-sided (as in the traditional inventory model), is not important for the current paper. While  $(S, s)$  models represent good characterizations of microeconomic behaviour, they are certainly not good descriptions of aggregate time series. In the next section I will discuss aggregation, which is a centrepiece for any model with microeconomic non-linearities, particularly  $(S, s)$  models.

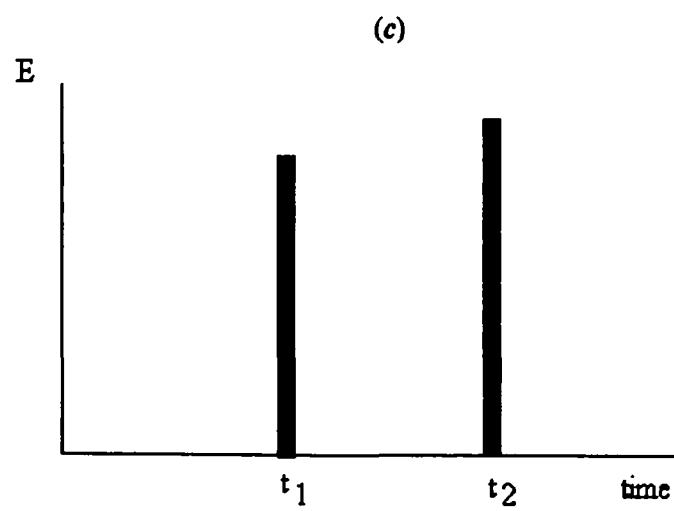
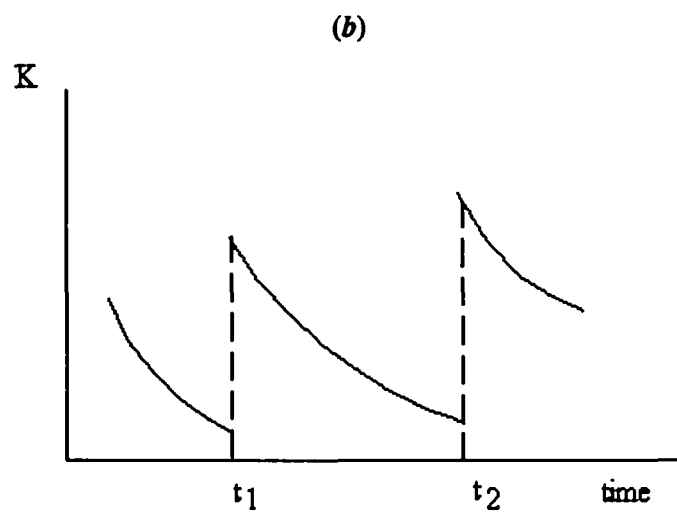
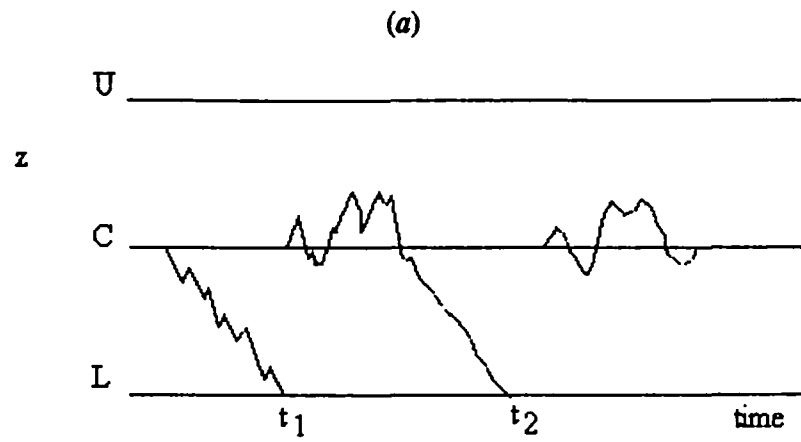
#### IV. AGGREGATE DYNAMICS

The long periods of inaction followed by sudden, dramatic adjustment of individual consumers which characterize  $(S, s)$  models changes the way we analyse aggregate dynamics. In particular, the number of units acting at any point in time or likely to act in the near future plays a key role in describing aggregate dynamics. In order to keep track of the number of units that are changing or about to change their stocks, one must keep track of the distribution of  $z$ s in the economy. This *cross-sectional distribution of disequilibria* (cross-sec-

<sup>9</sup> Depending upon the specific form of the non-convexity in the adjustment technology, adjustment may be less than full. This is not important for the point I am trying to emphasize here, which is the non-linear nature of the action-inaction pattern of microeconomic adjustment.

<sup>10</sup> Note that in general  $k^*$  will be different from the stock of durables the consumer would hold in the absence of frictions today *and* in the foreseeable future. The reason for this difference is that with future costs it will take some time before a new adjustment takes place, while in the frictionless case there is continuous adjustment.

**Figure 1**  
**Adjustment Paths for Expenditure and Stocks**



tional distribution, for short) plays a key role in aggregate ( $S,s$ ) models.<sup>11</sup> Most of the developments in the recent ( $S,s$ ) literature have improved our understanding and modelling of the factors behind the evolution of this cross-sectional distribution. In particular, new empirical methodologies have been designed to incorporate information (empirical or theoretical) on the path of this distribution in aggregate empirical equations.

The full analysis of the dynamics of the cross-sectional distribution can be technically difficult, especially when described in continuous time where the results are cleanest (see e.g. Caballero, 1993). This is beyond the scope of these notes. Instead, I will provide the basic intuition for some of the mechanisms at work using a discrete time-continuous state space example.

We begin by listing the timing of forces driving changes in individual disequilibria. Let  $z_{t-1}$  denote a consumer's disequilibrium at the end of period  $t - 1$  and  $z_t$  the disequilibrium at time  $t$  after depreciation,  $\delta$ , and the aggregate shock,  $v_t$ , have taken place. Period  $t$  ends with discrete upgrade if  $z_t$  is less than  $L$  and downgrade if  $z_t$  exceeds  $U$ , and a subsequent idiosyncratic shock,  $\epsilon_t$ , resulting in  $z_t^*$ . Denoting the corresponding cross-sectional densities by  $f^*(z, t - 1)$ ,  $f(z, t)$ , and  $f^*(z, t)$  and letting capital letters denote the corresponding distribution functions, we have:

$$f(z, t) = f^*(z + \delta + v_t, t - 1), \quad (6)$$

$$f^*(z, t) = [F(L, t) + 1 - F(U, t)] g_t(C - z) + \int_{L-z}^{U-z} f(z + \epsilon, t) g_t(\epsilon) d\epsilon, \quad (7)$$

where  $g_t(\cdot)$  denotes the density of idiosyncratic shocks at time  $t$ . Equation (6) describes the horizontal shift in the cross-sectional density owing to depreciation and the aggregate shock: consumers who had a disequilibrium  $z + \delta + v_t$  at the end of period  $t - 1$ , land at a disequilibrium  $z$  after depreciation and the aggregate shock. Equation (7) summarizes the two steps that follow the transition from

$f^*(\cdot, t - 1)$  to  $f(\cdot, t)$ : adjustments and idiosyncratic shocks. It first distinguishes between those that adjust and those that do not. Among the former, there are  $F(L, t)$  of them that upgrade their stock of durables and  $1 - F(U, t)$  that downgrade theirs. All those upgrading land momentarily at the target point,  $C$ , and a fraction,  $g_t(z - C)$ , of them end up at  $z$  after receiving an idiosyncratic shock equal to  $C - z$ .<sup>12</sup> This explains the first term in equation (7). The second term corresponds to the contribution of all those who do not adjust. After receiving an idiosyncratic shock equal to  $\epsilon$ , an individual with a disequilibrium  $z + \epsilon$  lands at  $z$ : a fraction  $g_t(\epsilon)$  of the  $f(z + \epsilon, t)$  individuals at  $z + \epsilon$  receive such a shock. Summing over all relevant idiosyncratic shocks,<sup>13</sup> yields the expression in the equation.

Given the initial cross-sectional density, the distribution of idiosyncratic shocks, and the microeconomic policies, one can use equations (6) and (7) to characterize the dynamic response of the cross-sectional density to aggregate shocks. In these notes the only reason to be concerned with the cross-sectional density is for its role in determining aggregate dynamics. Changes in the aggregate stock of durables are brought about by three forces: depreciation ( $\delta K_{t-1}$ ), gross upgrading, and downgrading flows ( $I_t$  and  $D_t$ ).

$$\Delta K_t = I_t - D_t - \delta K_{t-1}, \quad (8)$$

with

$$I_t = \int_{-\infty}^L (C - z) f(z, t) dz \quad (9)$$

$$D_t = \int_U^{\infty} (z - C) f(z, t) dz \quad (10)$$

where  $(C - z)$  is the size of the adjustment of those that cross the trigger thresholds.

It should be apparent that with meaningful heterogeneity—reflected in a sufficiently spread-out cross-sectional distribution at all times—aggregate dynamics are characterized by continuous gross flows. Thus there are no intermittent actions, which

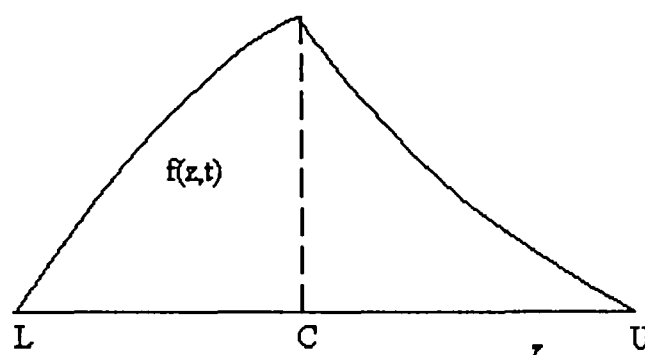
<sup>11</sup> The importance of this cross section is not only important for ( $S,s$ ) models, of course. Any model that exhibits microeconomic nonlinearities with respect to  $z$  will require information on higher moments of the distribution of disequilibria as long as there is meaningful and realistic heterogeneity.

<sup>12</sup> Remember that idiosyncratic shocks to the desired stock of durables shift the disequilibrium in the opposite direction.

<sup>13</sup> That is, over shocks that bring to the point  $z$  individuals who have not adjusted.



**Figure 2**  
**Typical Average of the Cross-sectional Distributions Arising from the Continuous Time ( $S,s$ ) Models for Durable Goods**



would be counterfactual at the aggregate level. In what follows I will illustrate the mechanisms behind aggregate sluggishness and persistence by discussing the flow of upgrades, since the analysis for downgrades is equivalent. Alternatively, we can make investment in durables irreversible, so  $U$  tends towards infinity. Below, I assume that  $U$  is very large.

Intuition suggests a plausible justification for sluggish aggregate adjustment to aggregate shocks. While aggregate shocks affect all consumers, only a fraction  $f(L,t) < 1$  adjust in the current period. This intuition is almost right, but it sometimes can be misleading. A famous counterexample is due to Caplin and Spulber (1987). Suppose that  $f(L,t) = 1/(C-L)$ , that there are no consumers with  $z < L$ , and that the aggregate shock,  $v_t$ , is small. Then the size of the jump of those that adjust is  $(C-L)$  and the number of consumers adjusting is approximately  $v_t f(L,t) = v_t/(C-L)$ . Thus,

$$\Delta K_t \approx (C-L) \{v_t/(C-L)\} = v_t,$$

and there is no aggregate friction, in spite of lumpy microeconomic adjustment. The basic message of this example is that, once again, the shape of the cross-sectional distribution plays a key role in determining aggregate dynamics. Caballero (1992)

shows that explicitly modelling the endogenous behaviour of this cross-sectional distribution uncovers many fallacies of composition present in standard analysis of adjustment cost models.

The example above can also be used to demonstrate that if  $f(L,t) < 1/(C-L)$ , the intuition on the source of sluggishness given above is confirmed. This is important, for probabilistic structures more realistic than that considered by Caplin and Spulber (1987) (in particular, with meaningful ratios of idiosyncratic uncertainty to drift) typically lead to cross-sectional densities that obey the previous inequality. Figure 2 shows a typical average of the cross-sectional distributions arising from the continuous time ( $S,s$ ) models for durable goods (see e.g. Caballero, 1993).

Associated with the recent developments in modelling the cross-sectional distribution have been efforts at structural empirical estimation of these models.<sup>14</sup> The first attempt that I am aware of is due to Bertola and Caballero (1990). They implemented a discrete Markov chain model with consumers following  $(L,C,U)$  policies and found that the model was able to replicate post-war US quarterly aggregate expenditure on durables remarkably well: over 85 per cent of the departure from the frictionless model could be explained by a model

<sup>14</sup> See Bar-Ilan and Blinder (1992) for less structural but very insightful evidence and procedures.

with an (estimated) inaction range ( $U-L$ ) of 52 per cent and an idiosyncratic uncertainty of 13 per cent. Caballero (1993) provided a continuous time representation and empirical apparatus, and showed that the  $(L,C,U)$  model could not only explain the serial correlation of aggregate purchases, but could also account for differences in the dynamic behaviour of different categories of durables and the instability of the observed serial correlation patterns. Specifically, aggregate furniture purchases were found to be more sluggish than automobile purchases. This seems reasonable, given larger secondary market imperfections (or adjustment costs) for furniture than for automobiles. Second, durable purchases were found to be more sluggish during the 1970s; the model explains this with a lower growth rate of desired durables, which reduced the fraction of consumers close to the upgrading threshold.

The previous results were obtained using aggregate data only, together with strict assumptions on the underlying stochastic structure. But one can also use this framework to organize microeconomic data. This is precisely what Eberly (1993) did. Using 2,400 observations from the Survey of Consumer Finance, she showed that microeconomic purchases of automobiles are indeed intermittent and lumpy. She documented that, on average, consumers wait until their automobile is about half their desired level before upgrading. This implies a larger inaction range than that estimated by Bertola and Caballero (1990) for total durable purchases, but consistent with the estimates for cars obtained with aggregate data by Caballero (1993). This consistency unveils one of the features I find most appealing in these types of models: that it is possible to go back and forth from microeconomic data to macroeconomic data, stopping at any desired level of aggregation if the data are available. This cannot be done with the standard representative agent models because the representative agent is already a non-explicitly modelled average which does not represent individual microeconomic units.

## V. CONCLUSION AND ONGOING RESEARCH

These notes are far from comprehensive. They just highlight a few important issues within an emerging literature, aimed at understanding aggregate dynamics when microeconomic units face fixed costs of adjustments. Durables goods are perhaps the most natural example within this literature.

I have not reviewed at full length the empirical implementation of  $(S,s)$  models. This is one of the areas that has exhibited most progress lately. In Bertola and Caballero (1990) the objective was only to show that one could indeed generate aggregate dynamics resembling aggregate data starting from realistic intermittent and lumpy microeconomic purchases. By now, fully specified maximum likelihood procedures allow us to test properly the aggregate fit of these models against standard alternatives (see Caballero and Engel, 1994). The results are very encouraging, with  $(S,s)$ -based models being substantially better than their linear counterparts at fitting sharp recessions and brisk expansions.

On the theoretical end there are still a few unanswered questions. What is the precise nature of adjustment cost? If secondary market imperfections is the answer, how does this market respond to the evolution of the cross-sectional distribution of disequilibria and consumers' actions? And, more generally, how should suppliers of durables use the information on the cross-sectional distribution of disequilibria? Although these are technically difficult questions to answer, I have little doubt that they will be answered soon. I am more worried, however, with what we may be asking consumers and producers to do when solving these general equilibrium models; asking them to use information on an entire cross-sectional distribution may be stretching the rational expectations hypothesis. I suspect, sooner or later, improvements on the theoretical side of these models may require dealing with issues of bounded rationality.

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