Discussion of 'Optimal Monetary Policy with Durable and Non-Durable Goods,' by Christopher J. Erceg and Andrew T. Levin*

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International Research Forum on Monetary Policy
European Central Bank, Frankfurt
July 5-6, 2002

1 Introduction

First, I would like to thank the organizers for giving me the opportunity to contribute to an outstanding conference.

The paper by Chris and Andy that I am discussing is a very nice, extremely interesting contribution to a growing literature on models with multiple sectors, exemplified by Aoki (2001), Benigno (2001)–whose setup I like to reinterpret as a multi-sector rather than a multi-country economy–and myself in recent work with Chuck Carlstrom and Tim Fuerst (2002*a*, *b*).

Differently from these papers, one of the sectors in Chris and Andy's model produces consumer durables.

VAR evidence in the paper shows that durables consumption is more interest rate sensitive than non-durables consumption.

Chris and Andy ask two key questions:

- What is optimal monetary policy in a model that replicates this feature of the data?

*The original transparencies for this discussion were hand-written using transparency markers. Along with thanking the organizers–Ignazio Angeloni, Matt Canzoneri, Dale Henderson, and Axel Weber–for inviting me to this conference, special thanks go to Dale Henderson for being the first (and only) discussant in the first day of the conference to use old-fashioned, hand-written transparencies for his discussion. Before his discussion (and after a display of mighty PowerPoint technology and nicely typed transparencies by a number of discussants), I was rather in a panic at the idea of being the only discussant with hand-written transparencies–and a junior scholar at that. Dale's transparencies greatly contributed to my ability to sleep (and thus my welfare) in the night before my own discussion.

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- How far are simple rules from optimal policy in terms of performance?

Here are their answers:

- Optimal monetary policy reacts to sector-specific inflation rates and output gaps.
- Inflation targeting (strict) performs poorly.
- Aggregate output gap targeting performs quite well.

I have two main comments on this paper, followed by some additional remarks. The main observations concern:

- The model of durables consumption.
- Relative price dynamics and endogenous persistence.

I will begin from the latter.

2 Relative Price Dynamics and Endogenous Persistence

A key insight of multi-sector models a la Benigno (2001) is that different degrees of nominal rigidity across sectors generate endogenous persistence through terms of trade dynamics.

Carlstrom, Fuerst, and Ghironi (2002*b*) study the dynamics of the economy following sectoral productivity shocks in a sticky-price model that shares several key features with Benigno's work. The main assumptions are as follows:

- Two sectors, both producing non-durable goods.
- Standard monopolistic competition, Calvo pricing.
- Cash-in-advance (CIA) timing for real balances in the utility function, as opposed to the usual cash-when-I-am-done (CWID) case, in which the real balances that matter for utility are those with which agents leave the goods market. Under CIA timing, real balances that matter are those with which agents *enter* the goods market. Carlstrom and Fuerst (2001) show that the timing of real balances in the utility function has consequences for the determinacy properties of interest rate rules. Forward-looking rules that ensure determinacy under CWID timing result in indeterminacy under CIA timing.
- Suppose the nominal interest rate, r_t, is set according to:

$$r_t = \tau_1 b \pi^1_{t-1} + \tau_2 (1-b) \pi^2_{t-1} + \tau_c c_{t-1}, \quad \tau_1,\ \tau_2 > 1, \quad \tau_c > 0,$$

where π_t^i is inflation in sector i ($i = 1, 2$), b is the weight of sector 1 in the consumption basket (so that, if $\tau_1 = \tau_2$, the central bank is actually reacting to CPI inflation), and c_t is aggregate consumption (equal to output in equilibrium).

- Let φ_t^i denote productivity in sector i ($i = 1, 2$), assumed to follow an $AR(1)$ process. p_t^i is the price of the sub-basket of differentiated goods produced in sector i. Then, $T_t \equiv p_t^1 - p_t^2$ denotes the terms of trade between the two sectors.

The solution of the model can be written as follows:

$$\begin{aligned}
\pi_t^1 &= \alpha_1 T_{t-1} + \gamma_1 \varphi_t^1 + \gamma_2 \varphi_t^2, \\
\pi_t^2 &= \alpha_2 T_{t-1} + \gamma_3 \varphi_t^1 + \gamma_4 \varphi_t^2, \\
c_t &= \alpha_3 T_{t-1} + \gamma_5 \varphi_t^1 + \gamma_6 \varphi_t^2, \\
\pi_t &= \left[b\alpha_1 + (1-b)\,\alpha_2\right] T_{t-1} + \left[b\gamma_1 + (1-b)\,\gamma_3\right] \varphi_t^1 \\
&\quad + \left[b\gamma_2 + (1-b)\,\gamma_4\right] \varphi_t^2, \\
T_t &= (1 + \alpha_1 - \alpha_2)\, T_{t-1} + (\gamma_1 - \gamma_3)\, \varphi_t^1 + (\gamma_2 - \gamma_4)\, \varphi_t^2.
\end{aligned}$$

If nominal rigidity is identical across sectors ($\lambda_1 = \lambda_2$ in the notation of Carlstrom, Fuerst, and Ghironi, 2002*b*) and the central bank reacts to CPI inflation ($\tau_1 = \tau_2$) $\Rightarrow b\alpha_1 + (1-b)\,\alpha_2 = \alpha_3 = 0$: There is no endogenous persistence in π_t and c_t.

Figure 1 shows the consequences of a productivity shock in sector 2 for aggregate consumption, inflation, and the nominal interest rate under the following parameterization of the model: β (the discount factor) $= .99$, $\lambda_1 = 1.3$, $\lambda_2 = .3$ (prices are stickier in sector 2), $b = .9$ (sector 1 has a significantly larger share in the consumption basket), $\rho_1 = \rho_2 = .9$ (shocks are persistent), $\tau_1 = \tau_2 = 1.1$, $\tau_c = .5$.[1] Endogenous persistence results in a hump-shaped response of aggregate consumption to the shock. No hump would be observed if it were $\lambda_1 = \lambda_2$.

Chris and Andy's model has the ability to generate endogenous persistence through this type of channel.

But:

Chris and Andy assume identical nominal rigidity across wages and prices and across sectors in their quantitative exercise, thus giving up this channel for endogenous propagation of shocks over time.

In Figures 1 and 2 of the paper, reporting the results of VAR estimation, the peak reaction of durables (and non-durables) consumption to an interest rate shock happens a few periods after the shock–a familiar hump-shaped pattern.

That pattern does not show up in Figure 3, showing model-based impulse responses, where the largest quantity reaction happens on impact. (The size of

[1] In the figure, C is aggregate consumption, PI is CPI inflation, R is the nominal interest rate, and PHI2 is productivity in sector 2.

the cost of adjusting durables in the model–ϕ–seems calibrated to match the different amplitude of peak responses in durables and non-durables rather than durables persistence.)

- Would allowing for different degrees of nominal rigidity across sectors improve the quantitative performance of the model even further?

- How would it affect the normative conclusions? (Benigno and López-Salido, 2001, find that output gap targeting performs well in a model that allows for differences in nominal rigidity. Nevertheless, it would be interesting to see whether these would affect Chris and Andy's results substantially.)

3 Models with Consumer Durables

The cost of adjusting the durables stock plays an important role in the model. Yet, it would be important to delve deeper into the foundations of a model with durables consumption.

It is plausible to think that adjusting one's stock of durables is costly. But is a quadratic specification the best choice? As it is, the model of durables behavior in Chris and Andy's setup is very similar to having an investment good sector in which capital is subject to familiar quadratic adjustment costs.

In cases in which adjusting durables simply entails replacement or upgrading (say, moving to a larger house), perhaps a fixed cost would be sensible. Recent personal experience taught me that it is hard to smooth the costs of buying a house and moving into it over time, as a quadratic cost would imply.

Let us also think about the following intuition. In a model without adjustment costs, the optimality condition for the allocation of spending between durables and non-durables relates the marginal utility from non-durables consumption to the marginal utility from durables consumption and the user cost. Interest rate movements trigger larger movements in durables consumption than in non-durables consumption because of changes in the user cost. A cost of adjusting durables generates incentives to smooth consumption of durables over time, thus dampening the reaction to a shock. Thus, on one side Chris and Andy introduce durables in the economy to have a sector that is more interest rate sensitive than the non-durables sector. On the other side, they rely on the adjustment cost to dampen otherwise excessive sensitivity. As suggested above, one wonders whether this is really different from having an investment good sector with a cost of adjusting capital.

Do we really need adjustment costs in a model that includes consumption of durables? If we need them, is the quadratic specification appropriate?

Fernández-Villaverde and Krueger (2001) provide an alternative approach. Agents choose $t+1$ durables at time t in their model, as in Chris and Andy's. There is no adjustment cost.

3.1 Durables as a Collateralizable Asset

- Fernández-Villaverde and Krueger develop a dynamic, general equilibrium model with idiosyncratic income shocks and *endogenous borrowing constraints*.
- Durables play two roles:
  - They provide consumption services.
  - They act as collateral for loans.
- The model explains/matches empirical regularities in household consumption and asset accumulation decisions. Specifically, it generates a hump-shaped profile of consumption over the life cycle and accumulation of durables earlier in life, followed by accumulation of financial assets at later stages.

The role of durables as collateral for loans could explain the higher sensitivity of durables output/consumption to interest rate movements that Chris and Andy find in the data in a world in which financial markets are imperfect.

3.1.1 The Fernández-Villaverde and Krueger Model

The main assumptions are as follows:

- Blanchard (1985)-type demographics. New individuals enter the economy at each point in time. Each individual lives at most J periods. In each period $j \leq J$ of an individual's life, the conditional probability of surviving and living in period $j+1$ is $\alpha_j \in (0,1)$, with $\alpha_0 = 1$ and $\alpha_J = 0$. α_j is out of the individual's control. It also measures the (deterministic) fraction of agents who, having survived until age j, will survive to age $j+1$, *i.e.*, a law of large numbers holds.
- One final good, produced according to the aggregate production function $F(K_t, L_t)$, where K_t is aggregate capital and L_t is aggregate labor.
- The final good can either be consumed or invested into physical capital or consumer durables. The economy's resource constraint is:

$$C_t + K_{t+1} - (1-\delta) K_t + K_{t+1}^d - \left(1-\delta^d\right) K_t^d = F(K_t, L_t),$$

  where C_t is aggregate consumption, K_t^d is the aggregate stock of durables, and δ (δ^d) is the rate of depreciation of capital (durables).
- Individuals supply labor inelastically.
- They differ in labor productivity due to age and idiosyncratic uncertainty.

- They value streams of non-durable consumption and durables according to:

$$E_0 \left[\sum_{j=1}^{J} \beta^{j-1} u\left(c_j, k_j^d\right) \right],$$

where lower-case letters refer to individual agents.

- Individuals are subject to constraints that limit short-sales of capital.

Dropping time subscripts and using a prime to denote next period's variables, households solve the recursive problem:

$$\begin{aligned}
V\left(k, k^d, \eta, j\right) &= \max_{c, k', k^{d'}} \left[u\left(c, k^d\right) + \beta \alpha_j \sum_{\eta'} \pi\left(\eta' \mid \eta\right) V\left(k', k^{d'}, \eta', j+1\right) \right] \\
& \quad s.t. \\
c + k' + k^{d'} &= w \eta \varepsilon_j + (1+r) k + \left(1 - \delta^d\right) k^d + Tr, \\
c &\geq 0, \quad k^{d'} \geq 0, \\
k' &\geq \overline{b}\left(k^{d'}, \eta, j\right),
\end{aligned}$$

where w is the real wage, r is the rental rate on capital, $\{\varepsilon_j\}_{j=1}^{J}$ is the age profile of average labor productivity, η is stochastic and obeys a finite state Markov chain ($\pi\left(\eta' \mid \eta\right)$ is the probability of η' tomorrow given η today), and Tr denotes transfers from accidental bequests.[2]

$k' \geq \overline{b}\left(k^{d'}, \eta, j\right)$ is a borrowing constraint. In the benchmark specification, $\overline{b}\left(k^{d'}, \eta, j\right)$ is the smallest number that satisfies:

$$V\left(\overline{b}\left(k^{d'}, \eta, j\right), k^{d'}, \eta', j+1\right) \geq V\left(0, 0, \eta', j+1\right) \quad \forall \text{ possible } \eta'.$$

Households can borrow up to the point at which, for all possible realizations of the productivity shock tomorrow, they have an incentive to repay their debt rather than default, with the default consequence specified as losing their capital and their durables.

It follows that durables are a collateralizable asset against which agents can borrow.

This seems a very plausible characterization of durables. Recall the observation that, as Chris and Andy's model stands, durables seem to be like capital, subject to adjustment costs, but they show up in utility rather than production, as a second type of consumption. The Fernández-Villaverde and Krueger

[2] There are no annuity markets. Accidental bequests are distributed uniformly across all agents currently alive.

approach would bring net worth considerations into the analysis of household behavior in a realistic fashion.

A borrowing constraint would amplify the interest rate effect in the condition that relates non-durables and durables consumption.

What about the feasibility of incorporating this type of setup in a monetary business cycle model for policy analysis?

Here I will plug the work of a colleague to be, Matteo Iacoviello. The framework he developed in his 2001 job market paper incorporates the role of durables as a collateralizable asset in a monetary business cycle model suitable for policy analysis.

4 Additional Comments

4.1 Inflation Targeting

Chris and Andy refer to inflation targeting in their paper as the policy that keeps aggregate consumer price inflation at zero in all periods. A result of the paper is that this policy performs very poorly on welfare grounds.

But this type of strict inflation targeting is not what, say, Lars Svensson would recommend as good policy. This is a point that needs to be clarified if the message of the paper is not to be misinterpreted. Svensson (2002) advocates the commitment to a targeting rule centered on the idea of flexible inflation targeting. Thus, the commitment is, first and foremost, to a loss function to be minimized with respect to the paths of the variables that are featured in it, with inflation not necessarily hitting a point target in all periods.

In fact, Svensson's idea seems closer to the concept of optimal monetary policy in Chris and Andy's paper than to what they call inflation targeting: the commitment to an objective function to be optimized by proper choice of inflation and output gap paths. The problem with this interpretation would be a blurring of the definition of inflation targeting. Taken literally, the interpretation would imply that inflation targeting is *always* the optimal policy on welfare grounds, as it is always the policy that maximizes welfare, whatever the determinants of this across different models.

Perhaps, an intermediate approach would be helpful. Strict inflation targeting as in the current version of the paper could be compared (in terms of business cycle properties and welfare) to inflation targeting as an instrument rule in which the interest rate reacts mainly to inflation (although Svensson criticizes this approach) and a version of inflation targeting a la Svensson, in which the paths of inflation and output gap are those implied by minimization of a loss function defined over, say, the volatility of an indicator of aggregate inflation and the output gap. If nominal rigidity differs across sectors, the aggregate inflation measure in the loss function could then be determined following the insights from Benigno's (2001) paper.

4.2 Estimation?

The paper relies on calibration for its quantitative exercise. It may be interesting to take the model to the data in a more direct fashion at a later stage. Ireland's (1999) "method for taking models to the data" combines the rigor of a dynamic, stochastic, general equilibrium (DSGE) model with the flexibility of VAR econometrics. It would be interesting to try to uncover parameter values from the data in that fashion, for example, obtaining a maximum likelihood estimate of the size of the durables adjustment cost, ϕ.

4.3 Higher Order Approximation? More Details on Policy Rules?

Kollmann (2002) is an example of solution of a DSGE model through higher-order approximation than log-linearization. Higher-order approximation seems particularly relevant for welfare analysis. I would be interested in seeing if and how results are affected by the adoption of Kollmann's method.

Finally, I believe the representative reader would benefit from the inclusion of more detailed, analytic descriptions of the policy rules that are considered.

5 Conclusion

This is a very interesting, stimulating paper. I learned a lot from it and look forward to reading more of Chris and Andy's work.

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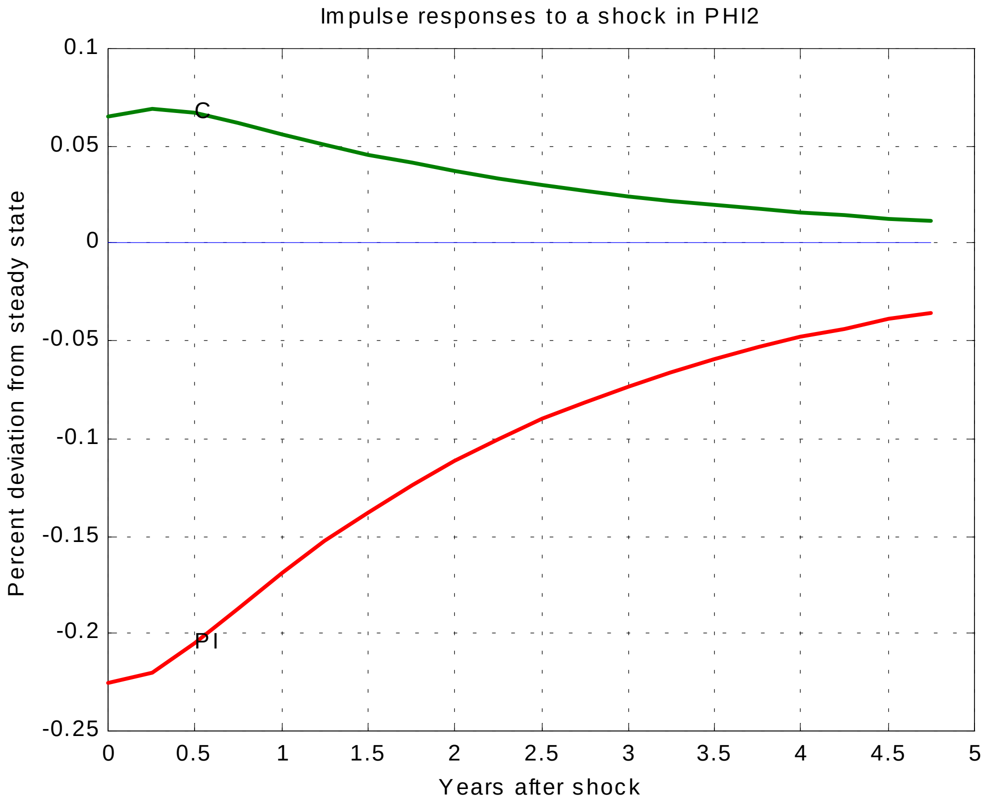
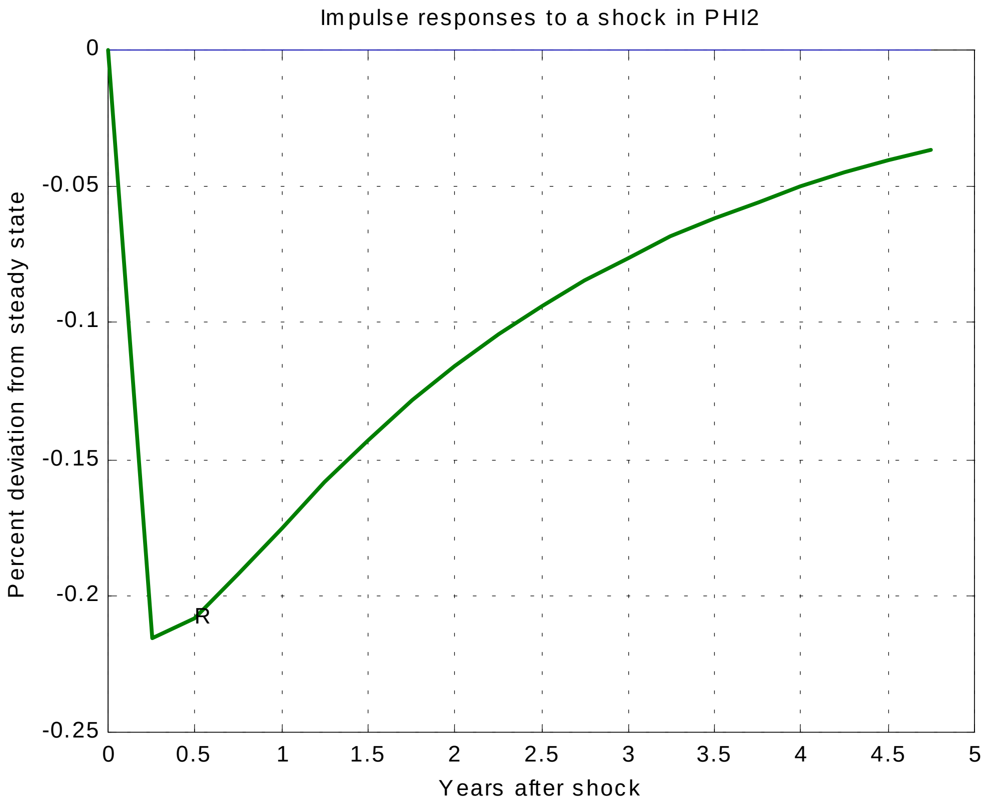
Figure 1


Impulse responses to a shock in PHI2
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.25
C
PI
0 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5
Years after shock
Percent deviation from steady state


Impulse responses to a shock in PHI2
0
-0.05
-0.1
-0.15
-0.2
-0.25
R
0 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5
Years after shock
Percent deviation from steady state