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Abstract

This article shows that the "risk premium" shock in Smets and Wouters (2007) can be interpreted as a structural shock to the demand for safe and liquid assets such as short-term US Treasury securities. Several implications of this interpretation are discussed.

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1. Introduction

In their seminal paper Smets and Wouters (2007) (hereafter referred to as SW) introduce a so-called "risk premium" shock into a medium-scale New Keynesian DSGE model. This shock was specified as an exogenous term appended to the representative household's linearized inter-temporal consumption Euler equation. As such the risk premium shock was not given a rigorous structural interpretation as it would have if it were specified as a feature of either preferences, technology or market structure. This is one reason Chari, Kehoe, and McGrattan (2009) cite to discredit the SW model.

The risk premium shock is important in New Keynesian DSGE models because of its capacity to generate business cycle co-movement among output, hours, consumption and investment. This makes it a significant driver of aggregate fluctuations and influences the identification of other shocks. Recent incarnations of the SW model used by Barsky, Justiniano, and Melosi (2014) and Christiano, Eichenbaum, and Trabandt (2014) find this shock is particularly important for post-2008 dynamics. If the shock is not plausibly structural then these and similar findings are difficult to interpret and the *ex ante* legitimate critique of this shock by Chari et al. (2009) stands.

The primary contribution of this article is to show how to re-interpret the SW risk premium shock as a structural shock to the demand for safe and liquid assets such as short-term Treasury securities. To do so I build on recent work by Krishnamurthy and Vissing-Jorgensen (2012) (KVJ). These authors describe a simple model of demand for the safety and liquidity of short-term Treasuries and use it to show the quantitative significance of these attributes. The structural interpretation that results from introducing their framework into the SW model suggests a new source of aggregate fluctuations that up until now has received relatively little attention – shocks to the demand for safe and liquid assets.[1] KVJ do not connect their framework to the SW model.

KVJ use episodic "flight-to-quality" as an example of safety and liquidity shocks. Chari et al. (2009) conjecture that the risk premium shock in SW may pick up variation in flight-

[1] Christiano, Motto, and Rostagno (2003) is an important exception as they show a similar shock is important for understanding the Great Depression.

to-quality as well. Unfortunately Chari et al. (2009) do not provide a foundation for why they believe this to be true. This article provides such a foundation. Doing so suggests new lines of research inquiry, including how to address potential flaws in SW's identification of the shock which become apparent only when a structural foundation is specified.

2. Interpreting the Shock

To demonstrate the structural nature of the SW shock we need only consider the household side of their model.[2] Since they are not consequential for the main result there is no growth, labor is homogeneous and consumption and leisure are separable in preferences that do not include habit. Using c_t and n_t to denote consumption and labor supply, and E_t to denote the date t conditional expectations operator, preferences for the representative household are

$$E_0 \sum_{t=0}^{\infty} \beta_t \left[\ln c_t + \eta \ln(1 - n_t) + s_t U(B_{t+1}/P_t)\right]. \tag{1}$$

The special feature of (1) is the term $s_t U(B_{t+1}/P_t)$ where $U(\cdot)$ is positive, increasing and concave. This represents the household's preference for holding one-period nominally risk free assets B_{t+1} that have unit price in dollars and pay a fixed nominal return R_t in period $t+1$. For simplicity we refer to these securities as *risk-free* bonds. The household cares about the real value of risk-free bonds and so the nominal quantity B_{t+1} is deflated by the price of consumption goods P_t. These preferences are similar to how KVJ model the various benefits derived from the liquidity and safety of short-term Treasuries and they are analogous to the money-in-utility approach pioneered by Sidrauski (1967).[3] The variable s_t is an exogenous stationary random disturbance. The main result is that under certain assumptions detailed below s_t corresponds to the SW risk premium shock. Safe and liquid assets being separable in (1) is essential to this result.

KVJ discuss why the liquidity and safety of short-term Treasuries justify including a

[2] Knowledge of the SW model is assumed throughout.

[3] The only difference with KVJ is that consumption and the safety and liquidity services derived from holding short-term Treasuries are not perfect substitutes in (1) while they are in KVJ.

motive for holding them in addition to the usual intertemporal substitution and risk aversion motives found in traditional representative agent asset-pricing models. The liquidity motive is justified by theoretical findings in Vayanos and Vila (1999) and Rocheteau (2009) who show how the price of assets with superior liquidity can command a premium and why the marginal liquidity service these assets provide is diminishing in the quantity of them held. KVJ describe three reasons why the perceived safety of short-term Treasuries also justifies a premium for holding them: costly acquisition of information on risky assets; their value as collateral in many financial transactions; and because they inherit the medium-of-exchange convenience of money via their use by commercial banks and money market funds as backing for checkable deposits. The function $U(\cdot)$ summarizes the derived demand for short-term Treasuries and other assets with similar characteristics generated by these factors, including fiat money. The variable s_t captures the idea that the demand for safe and liquid assets is time-varying.

The household maximizes (1) subject to a period-by-period budget constraint and the capital accumulation equation given by:

$$\begin{aligned} c_t + x_t + B_{t+1}/P_t &= r_t k_t + w_t n_t + R_{t-1} B_t/P_t + T_t; \\ k_{t+1} &= (1-\delta)k_t + (1 - Q(x_t/x_{t-1}))x_t. \end{aligned}$$

Here r_t and w_t denote the date t real rental rate on capital and the real wage, T_t denotes lump sum transfers to satisfy the government budget constraint, x_t denotes date t investment, k_{t+1} denotes capital installed for use in production at date $t+1$, and $Q(\cdot)$ is the adjustment cost function introduced by Christiano, Eichenbaum, and Evans (2005). Define λ_t to be the Lagrange multiplier on the budget constraint in the household's optimization problem which corresponds to the marginal utility of consumption.

The first order conditions for risk-free bonds and date $t+1$ installed capital can be written

$$\lambda_t - s_t U'(b_{t+1}) = E_t \beta \lambda_{t+1} \pi_{t+1}^{-1} R_t; \tag{2}$$

$$\lambda_t q_t = E_t \beta \lambda_{t+1} \{ r_{t+1} + q_{t+1} (1-\delta) \}. \tag{3}$$

The variables b_{t+1} and q_t denote the real quantity of bonds carried into $t+1$ and the price of date $t+1$ installed capital; $\pi_{t+1} \equiv P_{t+1}/P_t$ denotes consumer price inflation. The key feature of these equations is the extra term $s_t U'(b_{t+1})$ in the bond equation (2) and the absence of a similar term in the capital equation (3). Equation (2) is new while (the linearized version of) (3) appears in SW. An exogenous increase in s_t lowers the marginal cost of saving in the risk-free bond thereby increasing the incentive to save and save through this vehicle rather than via capital accumulation. The net result is a tendency for consumption and capital investment to move in the same direction. This is the underlying reason for why the SW shock plays such an important role in New Keynesian DSGE models.

Under certain assumptions the variable s_t is equivalent to the SW risk premium shock. To see this study the log linearized version of the first order condition for risk-free bonds equation (2):

$$\hat{\lambda}_t = \theta \left(\hat{R}_t - E_t \hat{\pi}_{t+1} + E_t \hat{\lambda}_{t+1} \right) + \lambda^{-1} U'(b) (s_t - s) + \lambda^{-1} s b U''(b) \hat{b}_{t+1}, \tag{4}$$

where $\hat{z}_t \equiv \ln z_t - \ln z$ for any variable z_t and the absence of a time subscript indicates the steady state value of a variable. The coefficient θ is the steady state discount on the risk-free interest rate relative to its value in the version of the model without a preference for the liquidity and safety of risk free bonds, $R^* \equiv \pi/\beta$:

$$\begin{aligned} \theta &\equiv \frac{R}{R^*} \\ &= 1 - \lambda^{-1} s U'(b) \\ &\leq 1 \end{aligned}$$

The inequality in the last line follows from the assumption that $s \geq 0$.

The bond equation in SW is obtained if we linearize around $s = 0$. In this situation $\theta = 1$ so that

$$\hat{\lambda}_t = \hat{R}_t - E_t\hat{\pi}_{t+1} + E_t\hat{\lambda}_{t+1} + \lambda^{-1}U'(b)s_t, \tag{5}$$

which corresponds to equation (2) in SW where the risk premium shock equals s_t scaled by the steady state marginal rate of substitution between consumption and risk free bonds, $\lambda^{-1}U'(b)s_t$.

Since no other equations of the SW model are affected by including a preference for safety and liquidity their results are unchanged by linearizing around $s = 0$. From this perspective the SW risk premium shock can be interpreted as a shock to the demand for safe and liquid assets. This sheds a whole new light on their findings and points research in a direction that has been given little attention in the recent business cycle literature. At the very least it suggests re-labeling the shock in SW. Calling it "safety and liquidity premium" is consistent with KVJ. Other possibilities include "liquidity preference" or "money demand." The latter is the shorthand used below.

3. Discussion

It may be more natural to linearize (4) around $b = 0$ with $U'(0) > 0$ and $s > 0$. In this case we obtain a slightly different version of (5),

$$\hat{\lambda}_t = \theta\left(\hat{R}_t - E_t\hat{\pi}_{t+1} + E_t\hat{\lambda}_{t+1}\right) + \lambda^{-1}U'(0)s_t.$$

If $s > 0$ then $\theta < 1$ and so in this case the direct connection to SW is broken. From this perspective interpreting the SW shock as a money demand shock requires an adjustment to the consumption Euler equation. To gauge the possible impact on measurement we can calibrate the adjustment factor θ using KVJ's estimates. KVJ find that the safety and liquidity of short-term treasuries translate to an average discount of 73 annualized basis points. This implies $\theta = .18$, which is much less than 1. Therefore not making the adjustment is a potentially serious source of miss-measurement of the money demand shock and its effects.

Another source of miss-measurement arises if we linearize around a positive value of b and we assume $U''(b) < 0$. Equation (4) with $b > 0$, $s > 0$ and $U''(b) < 0$ means that in addition to using the wrong value of θ the SW equation is missing a variable, namely the supply of safe and liquid assets, b_{t+1}. This would be consistent with the important role for the supply of these securities in determining their price found by KVJ. Still, the ultimate effects of accounting for the supply of safe and liquid assets for understanding business cycles remains to be determined.

While this article has developed a structural interpretation of the SW risk premium shock in the sense that it connects the shock to a preference for safe and liquid assets, these shocks are not plausibly structural if variation in the demand for safety and liquidity is mostly driven by other factors such as monetary policy shocks. Chari et al. (2009) assert a structural relationship between flight-to-quality and monetary policy. It is hard to imagine traditional monetary policy shocks *causing* a flight-to-quality, at least in the US. An example of reverse causality might be the liquidity facilities introduced by the Fed in the wake of the financial crisis. These policy actions have nothing to do with the interest rate setting function of monetary policy included in the SW model so that it is hard to see that shocks to the monetary policy rule within this model would be correlated with shocks to the demand for short-term Treasuries. The decline in activity brought on by events leading to the flight-to-quality would be accounted for by the policy reaction function and therefore poses no problem for identification.

These considerations notwithstanding the structural plausibility of money demand shocks as identified in DSGE models remains an open question. However the framework introduced here suggests a way forward for addressing this issue. For example, it suggests how to distinguish such shocks from monetary policy shocks by accounting for the supply of safe and liquid assets and the role of monetary policy in influencing this supply. Deeper modeling of the demand and supply of safe and liquid assets should help as well.

SW describe their shock as having "similar effects as so-called net-worth shocks in Bernanke, Gertler, and Gilchrist (1999) and Christiano et al. (2003), which explicitly model the external finance premium (p. 589)." The financial accelerator described in these papers may be an important channel by which money demand shocks are propagated to the rest of the economy. However, based on the findings of this article interpreting SW's risk premium shock as a shock to net-worth is misleading.

Barsky et al. (2014)'s and Christiano et al. (2014)'s findings interpreted through the lens of this article's framework means that money demand shocks account for a significant fraction of the post-crisis variation in aggregate data. This interpretation seems consistent with many accounts of the episode and therefore lends credibility to the New Keynesian framework used in these papers. Clearly a deeper foundation for the demand for safe and liquid assets is preferable to the nominally-risk-free-assets-in-utility approach taken here. Nevertheless the important role for the money demand shock in explaining business cycles suggests that developing a foundation that is amenable to the empirical analysis of aggregate data should be a high priority.

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