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A note on the potential pitfalls in estimating a 'wealth effect' on consumption from aggregate data

Jim Dolmas*

Federal Reserve Bank of Dallas, Research Department, 2200 North Pearl Street, Dallas TX 75201-2272, USA

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Abstract

This paper illustrates, by means of a simple equilibrium example, the problems in estimating a 'wealth effect' on consumption using only aggregate data on consumption and wealth. While the example echoes criticisms that date back to early work by the Cowles Commission, a spate of recent papers on this topic suggest that the lessons from that earlier literature have not been learned.

Keywords: Consumption; Wealth effect

JEL classification: E21; C22

The rise and fall of U.S. equity values since the mid-1990s has led to a renewed interest, particularly among policymakers and the business press, in the implications of changes in wealth for the behavior of aggregate consumption.[1] In response, there has been a spate of research, by academic economists and researchers within the Federal Reserve System, on various aspects of the 'wealth effect'. The empirical framework of many of these papers—though they may differ in focus and econometric technique—is single-equation estimation of an aggregate consumption function, in the spirit of Ando and Modigliani (1963).[2]

*Tel.: +1-214-922-5161; fax: +1-214-922-5194.

E-mail address: jim.dolmas@dal.frb.org (J. Dolmas).

[1] References to the 'wealth effect' pepper the speeches of members of the Federal Reserve's Board of Governors; a recent search of speeches at the Board's website turned up references to 'wealth effect' in 26 speeches by members of the Board since 1998. References in the business press are too numerous to quantify; characteristic are two front-page stories from the *Wall Street Journal,* one during the stock market's ascent phase (Ip, 1997), the second during its 're-entry' (Wessel, 2001).

[2] Models of this sort have been recently estimated by, among others, Ludvigson and Steindel (1999), Davis and Palumbo (2001), Mehra (2001), and Poterba and Samwick (1995). Poterba and Samwick, however, examine wealth effects due to stock market fluctuations not only within a single-equation/aggregate-data framework, but also by looking at household-level data. The points made in this note, clearly, apply only to their aggregate-level analysis.

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Is it possible to estimate the effect of changes in stock market wealth on aggregate consumption using only data on aggregate wealth and consumption? The point of this note is to illustrate, by way of an example, that such an estimation exercise is, at best, demanding of great care in the interpretation of results, and, at worst, subject to serious potential biases. The example I use is purposefully simple in order to highlight the main issues with a minimum of clutter. I even go so far as to assume that wealth is exogenous, which is clearly odd in any equilibrium model, but which biases the model's implications *in favor* of our ability to estimate a wealth effect from aggregate data. If serious problems arise even when wealth is exogenous, much more serious ones can be expected if we take account of the fact that wealth surely is endogenous. Also, while the exposition below is algebraic, one could as easily draw out most of the main implications in a simple supply and demand diagram.

Before proceeding, though, we should clarify what we mean by 'the wealth effect' on consumption. There are two possible interpretations—either the effect on *consumption demand* of a ceteris paribus change in wealth or the effect on *actual consumption* of a ceteris paribus change in wealth. What we will see below is that when wealth and any exogenous shocks to supply and demand are stationary—or, better, when the model sketched below is apropos to deviations of the relevant variables from trend—then we cannot, in general, estimate *either* type of wealth effect from aggregate data on consumption and wealth. If wealth has a stochastic trend, then, in the special case where the model is restricted to give a stationary real interest rate—which requires a cointegrating relationship between wealth and the shocks to aggregate supply—it is possible to estimate consistently the effect on *consumption demand* of a ceteris paribus change in wealth, though we will continue to remain in the dark as to the effect on *actual consumption* of a ceteris paribus change in wealth.

Consider, then, a simple neoclassical equilibrium model of a closed economy, a la Robinson Crusoe, ignoring investment and government consumption. Think of it is as a model with fruit trees, where people own claims to the trees, and work picking fruit; changes in the weather or exogenous changes in technology shift production possibilities from time to time. Suppose that the demand and supply of goods are given by

$$c_t^d = -\alpha r_t + \theta W_t + \xi_t^d \tag{1}$$

and

$$y_t^s = \beta r_t + \xi_t^s, \tag{2}$$

where r is the real interest rate, W is 'wealth', the ξ's are shocks, and the parameters $\alpha,\beta,\theta > 0$. Let us assume that ξ_t^d is orthogonal to wealth, W_t; this is not so unreasonable in this simple economy. However, since W_t derives (presumably) from households' claims to productive assets as well as the value of prospective labor income, it *would be unreasonable* to assume that W_t is orthogonal to the supply shock ξ_t^s.

Equilibrium in this simple economy is characterized by

$$c_t^d = y_t^s \tag{1}$$

or

$$-\alpha r_t + \theta W_t + \xi_t^d = \beta r_t + \xi_t^s, \tag{2}$$

implying that

$$r_t^* = \frac{1}{\alpha + \beta}\left(\theta W_t + \xi_t^d - \xi_t^s\right) \tag{3}$$

and

$$c_t^* = \frac{\beta}{\alpha + \beta}\theta W_t + \frac{\beta \xi_t^d + \alpha \xi_t^s}{\alpha + \beta}. \tag{4}$$

Now suppose that as econometricians we estimate

$$c_t = \gamma W_t + e_t \tag{5}$$

using OLS to try to uncover the effect of changes in wealth on either consumption demand or on actual consumption. We might use more sophisticated techniques, but this should not alter the basic problems, so long as our data consists solely of aggregate consumption and wealth. What will our estimation find? Our estimate by OLS will be

$$\begin{aligned} \hat{\gamma} &= (W'W)^{-1}W'c \\ &= \gamma + (W'W)^{-1}W'(c - \gamma W), \end{aligned}$$

where W and c denote the vectors of observations on wealth and consumption. Comparing (4) and (5), we see that

$$\gamma = \frac{\beta}{\alpha + \beta}\theta$$

and

$$c_t - \gamma W_t = \frac{\beta \xi_t^d + \alpha \xi_t^s}{\alpha + \beta}.$$

Thus, our estimate $\hat{\gamma}$ is actually

$$\hat{\gamma} = \frac{\beta}{\alpha + \beta}\theta + \frac{1}{\alpha + \beta}(W'W)^{-1}W'\left(\beta \xi^d + \alpha \xi^s\right).$$

Assume for now that W_t and the ξ_t's are stationary—that is, $I(0)$—processes; the case of stochastic trends will be considered further below. If the ξ's have mean zero, our estimate $\hat{\gamma}$ is approximately—in probability, for a large sample size—

$$\begin{aligned} \hat{\gamma} &\cong \frac{\beta}{\alpha + \beta}\theta + \frac{1}{\alpha + \beta}\,\frac{\operatorname{cov}\left(W, \beta \xi^d + \alpha \xi^s\right)}{\mathrm{E}\left(W^2\right)} \\ &= \frac{\beta}{\alpha + \beta}\theta + \frac{\alpha}{\alpha + \beta}\,\frac{\operatorname{cov}(W, \xi^s)}{\mathrm{E}\left(W^2\right)} \end{aligned} \tag{6}$$

where the second equality comes from the assumption that W is orthogonal to the demand shock ξ^d.

The most important thing to note about (6) is that $\hat{\gamma}$ is *neither* the marginal propensity to consume out of wealth (θ) *nor* is it the response of actual consumption to a change in wealth ($\beta/\alpha + \beta\theta$). If $\hat{\gamma}$ is supposed to be an estimate of θ—which is one of the two possible interpretations of what it means to 'estimate the wealth effect on consumption'—then it is biased and inconsistent in two ways. First, even if supply shocks and changes in wealth were orthogonal, we would have

$$E(\hat{\gamma}) = \text{plim}(\hat{\gamma}) = \frac{\beta}{\alpha + \beta}\theta < \theta,$$

so long as $\alpha \neq 0$. At the extreme, if $\beta = 0$—which would be the case if labor supply were unresponsive to changes in the real interest rate—we get $E(\hat{\gamma}) = 0$ regardless of the size of the marginal propensity to consume out of wealth, θ. A second bias comes from the correlation between wealth and the supply disturbances—which we suppose, is positive—and is opposite in direction from the first bias. Even if $\theta = 0$—i.e., the marginal propensity to consume out of wealth is zero—

$$\begin{aligned}\hat{\gamma} &= \frac{1}{\alpha + \beta}(W'W)^{-1}W'\left(\beta\xi^d + \alpha\xi^s\right)\\ &\cong \frac{\alpha}{\alpha + \beta}\,\frac{\text{cov}(W, \xi^s)}{\text{E}\left(W^2\right)} > 0 = \theta.\end{aligned}$$

When both biases are present, obviously, we cannot say what the relationship between $\hat{\gamma}$ and θ is.[3]

If, on the other hand, $\hat{\gamma}$ is meant to be an estimate of the response of actual consumption to a change in wealth—i.e., $\hat{\gamma}$ is intended simply to estimate $\beta/\alpha + \beta\theta$ from (4)—then it is only the latter problem, that which arises from the correlation between wealth and the supply shock ξ^s, which biases our results. In this case, from (6), we see that $\hat{\gamma}$ overstates the response of actual consumption to a ceteris paribus change in wealth. This is seen most clearly by considering again the case where $\theta = 0$: the response of actual consumption to a ceteris paribus change in wealth is zero, but $\hat{\gamma}$ is positive, if our sample size is large enough.

Now, suppose that wealth is an $I(1)$ process; in particular, suppose that wealth is the sum of a transitory component and a stochastic trend, say X_t. In this case, if the model parameters are restricted so that the r_t is a stationary process—which, from (3), amounts to requiring that the supply shock ξ_t^s contain a stochastic trend, θX_t, which cancels the trend in wealth—then OLS applied to (5) gives a consistent estimator of the marginal propensity to consume out of wealth, θ. This is the case since, from (1), consumption will be the sum of θW_t plus stationary variables, when r_t and ξ_t^d are stationary; well-known results for OLS regressions involving variables with stochastic trends guarantee that $\hat{\gamma}$ will converge in probability to θ. However, we are still unable to answer the question of what effect a ceteris paribus change in wealth—say an innovation to wealth's transitory component—will have on actual consumption. For that, as we know from (4), we require knowledge of α and β, but in this case, our regression provides no information on these parameters. Still, researchers seem to draw implications of wealth changes for the behavior of *actual* consumption.[4]

[3]If α were much smaller than β—so that $\beta/(\alpha + \beta)$ were close to one—then both biases might be negligible. In a deeper model, α and β would be related to individuals' willingness to substitute consumption and work effort over time, respectively, and there is no reason to suppose, a priori—nor any definitive micro-level evidence to suggest—that β is much larger than α or vice versa.

[4]See, for example, the concluding section of Davis and Palumbo (2001) or the introductory section of Ludvigson and Steindel (1999).

Obviously, one could conceive of more complicated examples, but I think the basic problems will persist and might, in fact, worsen. For example, one could add investment demand, but the innovations to investment demand should likely be correlated with the supply disturbances, hence with wealth, adding another source of bias and inconsistency. Another component of real-world aggregate demand, government purchases, is also absent. On top of all that, our exercise has been carried out under that pretense that wealth evolves exogenously.

The estimation problems which this example highlights are present in many cases where the parameters of interest are part of a supply and demand system—in fact, while the neoclassical character of the above example might have seemed out of place in the 1940s or 1950s, the potential problems which the example highlights would have been familiar to students of the Cowles Commission's case for structural estimation of systems of simultaneous equations.[5] Another alternative would be to abandon aggregate estimation altogether, and focus instead on the behavior of individuals or households. In any case, single-equation estimation involving aggregate quantities remains a less-than-ideal tool for uncovering the structure of macroeconomic relationships.

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[5] As captured in, *e.g.*, Haavelmo (1943).