Does the absence of demand side variability in stochastic partial equilibrium modeling bias outcomes? Facts and evidence from Brazil

Deepayan Debnath, Wyatt Thompson, Patrick Westhoff, and Scott Gerlt

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Deepayan Debnath, Wyatt Thompson, Patrick Westhoff, and Scott Gerlt

Food and Agricultural Policy Research Institute
FAPRI

Mizzou
University of Missouri - Columbia

Introduction

Deterministic analysis using an equilibrium model uses one set of exogenous data to generate one set of endogenous output. This approach might not always be the best choice, particularly if a policy has asymmetric consequences that depend on market conditions. Westhoff et al. (2006) argue that a single estimate under normal weather and macroeconomic conditions would estimate that a policy has no impact if the indicator of price or farm receipts did not hit the trigger level set by policy. These authors argue that the same policy might actually have expected payments greater than zero if assessed in the context of a range of possible weather and macroeconomic conditions, along with their consequent ranges of prices and farm receipts.

Stochastic analysis using an equilibrium model is an alternative to deterministic analysis that involves many model simulations for a range of input data. The basic concept behind the stochastic approach is to make random draws of exogenous variables and solve the model for each set of exogenous variables. This process generates many alternative outcomes for the endogenous variables. In applied work, it is likely impossible to vary all exogenous inputs, leading to partial stochastic analysis that varies a subset of the exogenous inputs. We know of no study to set out the criteria to be used when selecting exogenous variables.

Our hypothesis is that poor selection criteria can reduce the value of this method by introducing a bias. Specifically, if only supply-side exogenous variables are used to drive the stochastic analysis, then the results obtained from solving the stochastic partial equilibrium model might lead to biased estimates in some contexts.

Our objective is to investigate the consequences of not selecting exogenous variables for the random draws from the demand side in the stochastic partial equilibrium framework. Our application compares supply-only and more general stochastic methods in terms of their impacts on market outcomes and crop receipts.

Theoretical Framework

We develop a model of demand and supply for a commodity i in year t as described in the following equations:

$$QD_i^t = Int_d - \alpha P_i^t + \varepsilon_i^t; \quad \varepsilon_i^t \overset{iid}{\sim} N(0, \sigma_{\varepsilon_i^t}^2) \text{ , and} \quad (1)$$

$$QS_i^t = Int_s + \beta P_i^t + \varphi_i^t; \quad \varphi_i^t \overset{iid}{\sim} N(0, \sigma_{\varphi_i^t}^2). \quad (2)$$

At equilibrium, the solutions for price and quantities are

$$P_i^t = \frac{Int_d - Int_s}{(\alpha + \beta)} + \frac{\varepsilon_i^t - \varphi_i^t}{(\alpha + \beta)}, \text{ and} \quad (3)$$

$$QD_i^t = QS_i^t = \frac{\alpha Int_s + \beta Int_d}{(\alpha + \beta)} + \frac{\alpha \varphi_i^t + \beta \varepsilon_i^t}{(\alpha + \beta)}. \quad (4)$$

Assuming rational expectations, the expectation of crop receipts is conditional on the information available at time (t-1). Taking the conditional expectation of crop receipts, removing the terms $E(\varepsilon_i^t) = E(\varphi_i^t) = 0$, and replacing $E((\varepsilon_i^t)^2) = \sigma_{\varepsilon_i^t}^2$, and $E((\varphi_i^t)^2) = \sigma_{\varphi_i^t}^2$, we get:

$$E(R \mid I_{t-1}) = \frac{\alpha Int_s + \beta Int_d}{(\alpha + \beta)^2}(Int_d - Int_s) + \frac{1}{(\alpha + \beta)^2}[\beta \sigma_{\varepsilon_i^t}^2 - \alpha \sigma_{\varphi_i^t}^2] \quad (5)$$

Consider the case if the additive stochastic disturbance is from only the supply equation. There would not be any stochastic disturbance associated with the demand equation. Then the revised expected crop receipts conditional on the (t-1) information would be:

$$E'(R \mid I_{t-1}) = \frac{\alpha Int_s + \beta Int_d}{(\alpha + \beta)^2}(Int_d - Int_s) - \frac{\alpha \sigma_{\varphi_i^t}^2}{(\alpha + \beta)^2} \quad (6)$$

Therefore, comparing equation (6) and (7), we found:

$$E(R \mid I_{t-1}) > E'(R \mid I_{t-1}) \quad (7)$$

Empirical Model

A partial equilibrium model is developed for Brazil for corn and soybean markets. The model is comprised of behavioral equations and identities representing yield, harvest area, production, food and feed uses, exports, ending stocks, and market-clearing prices for both crops. Stochastic analysis is undertaken first with the supply-only approach: 500 sets of correlated random draws for corn and soybean yields are taken. The partial equilibrium model is simulated with each set separately to estimate how supply variation interacts with deterministic demand to generate prices. The next round of simulations goes beyond introducing the yield draws together to include random draws on error terms from demand equations. 500 sets of new outcomes for corn and soybean markets reflect 500 different contexts.
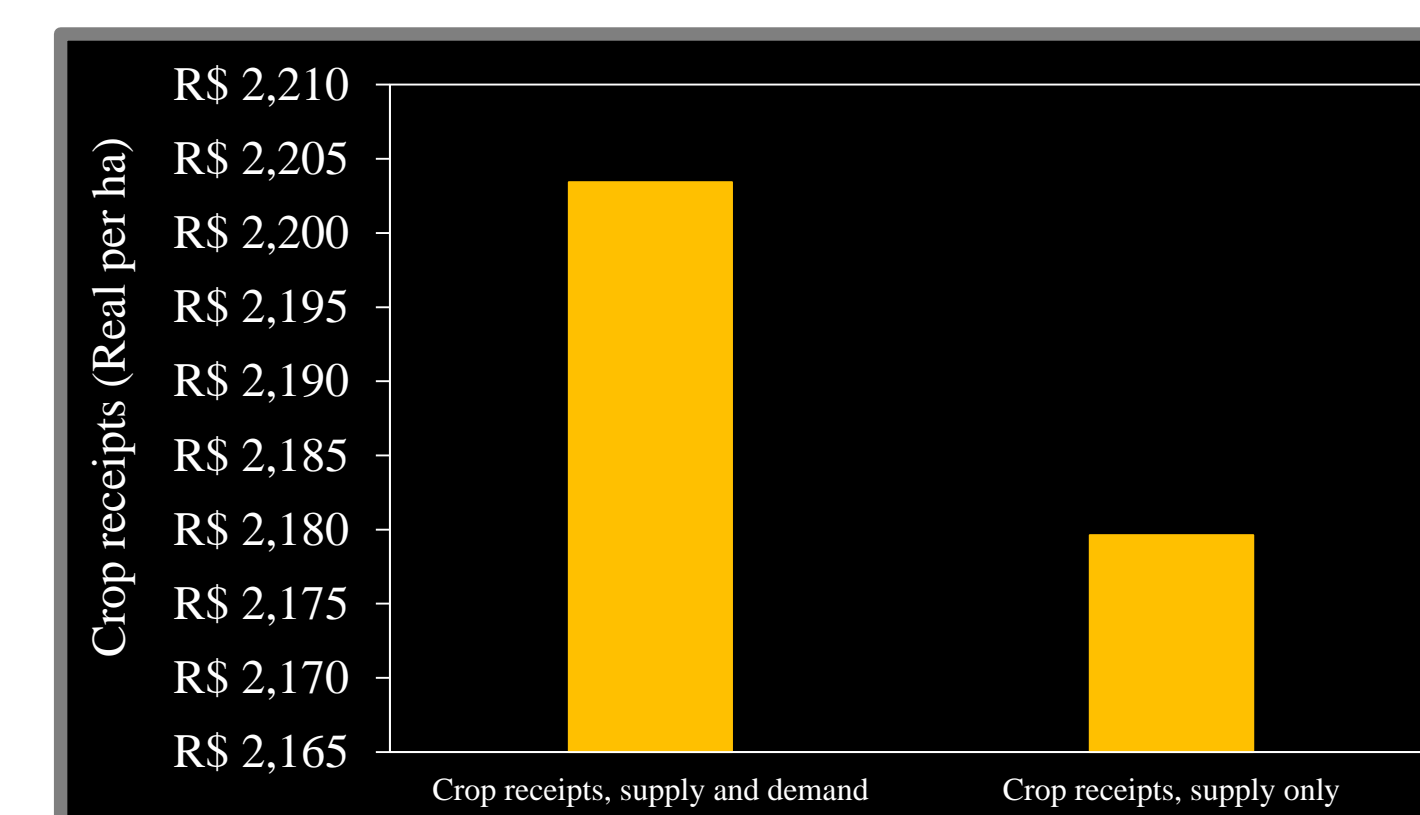
Results

Fig. 1: Comparison between crop receipts obtained from solving supply & demand and supply only stochastic model

The average crop receipts obtained from producing corn and soybean are R\$ 2,203 /ha when stochastic terms are introduced in both the supply and demand equation compared to R\$ 2,180 /ha obtained from supply-only stochastic model (fig.1).

Fig. 2: Comparison between 10th & 90th percentile of the crop receipts obtained from solving supply & demand and supply only stochastic model

Fig. 2 shows that the crop receipts are higher for supply and demand side stochastic model even for 10th and 90th percentile.
Both the theoretical (equation 7) and empirical (fig. 1-2) findings show that crop receipts could be lower if supply-only variability is considered in stochastic modeling.
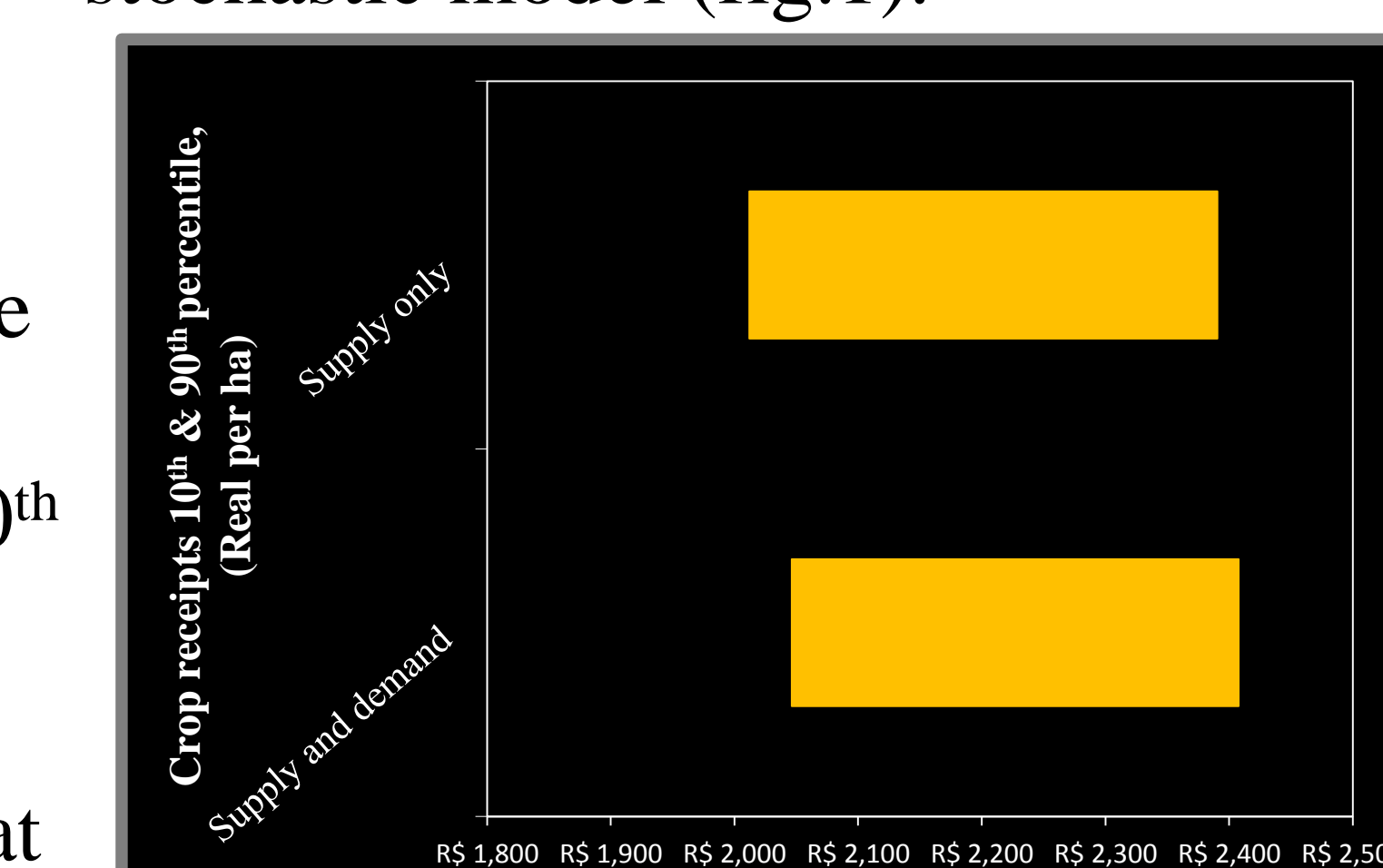
Conclusion

The United States Farm Bill includes new programs that have price or revenue triggers, suggesting that stochastic model analysis will have a priority in future work. This paper informs researchers' criteria for identifying the key variables for the stochastic analysis. Our findings show that supply-only exogenous variable in stochastic analysis could results in biased outcomes. Therefore, crucial policy measures, including government agricultural support programs, based on the supply-only stochastic analysis might bias estimated impacts on commodity market prices and crop receipts.

References

Westhoff., P., S. Brown and C. Hart (2006) When Point Estimates Miss the Point: Stochastic Modeling of WTO Restrictions. *Journal of International Agricultural Trade and Development* 2(1):87-109.

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