APPENDIX E OF THE SUPPLEMENTAL MATERIAL: LAND PRICES AND QUANTITY (*NOT INTENDED FOR PUBLICATION*)

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In this appendix we discuss some issues related to the measurement of land prices and quantities.

I. The price of land

The house value is composed of two diametrically different components: 1) the cost of structures that is specific to the cost of basic materials and the productivity of the construction industry relative to other sectors of the economy and 2) the price of land. As documented in Davis and Heathcote (2007), it is changes in the price of land, not those in the cost of structures, that constitute a driving force behind large house-price fluctuations at both low and business-cycle frequencies.

The land price in our benchmark model is based on the Federal Housing Finance Agency (FHFA) house price index. The FHFA series is used in the literature (Chaney, Sraer, and Thesmar (Forthcoming)) because it has a comprehensive geographic coverage. The FHFA publishes the house price index for each of all 50 states based on all transactions. The disadvantage of the FHFA series is that it covers only conforming (conventional) mortgages. On the other hand, the CoreLogic house price index series, provided by Core Logic Databases, has the same time-series pattern as the Case-Shiller-Weiss (CSW) house price index but covers far more counties than does the CSW house price index. Indeed, the CoreLogic data cover all 50 states and, unlike the FHFA data, include both conforming and nonconforming mortgages.

The purchase-only FHFA house price index (Haver Data key: USPHPI@USECON) is available only from 1991Q1 to present. For 1975Q1 to 1990Q4, the FHFA house-price index is spliced to be consistent with the purchase-only series. We then follow

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the methodology of Davis and Heathcote (2007) and compute the FHFA land price index. The series is seasonally adjusted.

Both FHFA and CoreLogic data are all transactions but the CoreLogic data include nonconforming mortgages. Why do we not use the CoreLogic data in place of the FHFA data? The reason is that the CoreLogic house price data have serious problems in the early part of the sample. First of all, the number of repeat sales in the early part of the sample is much less than the later part. For example, the total number of repeat sales per year as a percentage of the total number of existing single-family home sales from the National Association of Realtors doest no exceed 15% until 1980.

Second, the geographic coverage of the CoreLogic index is not as broad in the early part of the sample. For example, the CoreLogic index didn't include all states until 2000. By contrast, the FHFA publishes an all transactions state index for each of the U.S. states all the way back until 1975. Thus, the FHFA had comprehensive geographic coverage even in the early part of the sample.[1]

Third, CoreLogic overweighs certain states, especially California and Florida, in the early part of the sample. We compute the share of single family homes in the U.S. that are in California and Florida using the 10-year Census[2] and linearly interpolate them. Then we compute the share of repeat sales in the CoreLogic data by year that are in California and Florida. From 1976 to 1981, for example, roughly 40% of the sales in the CoreLogic sample are in California or Florida.

To overcome these problems in the early part of the sample, we seasonally adjust FHFA home price index for 1975Q1-1980Q4 and splice this index together with Haver Data's seasonally adjusted CoreLogic home price index for the third month of a quarter (Haver Data key: USLPHPIS@USECON) for 1981Q1 to present. We then follow the methodology of Davis and Heathcote (2007) and compute the CoreLogic land price index.

II. The quantity of land: model implications and some evidence

As we discuss in the paper (Section IV.3), our model implies a land-reallocation effect when the land price rises. The mechanism works in the following way. Following a positive housing demand shock, the land price rises and the entrepreneur's net worth

[1]Given the very large swings in FHFA home prices for some states in the early part of the sample, there probably exist small sample issues for some states early on.

[2]The data are available at `http://www.census.gov/hhes/www/housing/census/historic/units.html`

increases. The entrepreneur is able to borrow more to finance investment and production. As production expands, the entrepreneur needs to acquire more land and labor (as well as capital). The expansion in production raises the household's wealth and triggers competing demand for land between the household and the entrepreneur. Such competing demand for land further pushes up the land price. The extent to which land is reallocated depends on parameter values, although the competition for land between the two sectors raises the land price unambiguously.

In our estimated model, the entrepreneur ends up with owning moderately more land in equilibrium. Figure 1 shows the impulse responses land holdings by the household and by the entrepreneur following a positive housing demand shock. The figures shows that the quantity of land reallocated between the two sectors is small. With estimated parameters, the entrepreneur's land holdings increase by a bit less than 3% of total land (and symmetrically, the household's land holdings decrease by a bit less than 3% of total land).

To examine whether the model's land reallocation mechanism is empirically plausible, we need data on land quantities. Unfortunately, land quantity, especially commercial land quantity, is poorly measured and extremely unreliable. The main measures of land quantity that we can find are constructed by Davis and Heathcote (2007) based on data from the Bureau of Economic Analysis (BEA) and Bureau of Labor Statistics (BLS).

The BEA-BLS measure shows that total land quantity has grown slightly over time. If some residential land is converted into commercial land in periods when land prices boom, then we should expect to see residential land growth to slow down when land prices are rising. Figure 2 displays the real land price (left scale) and the growth rate of residential land (right scale). The figure is based on the CoreLogic data whose broad coverage of mortgage types is likely to improve the quality of the measurement of the land quantity, specially for the period after 1990. The figure shows that residential land growth slowed down substantially during the land-price booms in the first half of the 2000s. Since aggregate land supply grows slowly, we take this observation as suggestive evidence that land flows from the household sector to the business sector when land prices rise.

To obtain the quantity of commercial land directly, the best matched series is probably measured by the land in nonfarm business sector, which is available only on an annual basis. As the growth rate of commercial land before 2001 is extrapolated by the BLS relying on the strong assumption that land-structure ratios are based on data

from 2001 for *all counties in Ohio*, the quality of the series before 2001 is extremely poor because of this highly unreliable extrapolation. Even for residential land, Davis and Heathcote (2007) are most confident in their land estimate only from 2000 on. The BLS measure suggests that commercial land growth accelerated from a little under 1% in 2001 to about 2% in 2006 during the booming years of land prices. Thus, the available data do not seem to contradict our model's implications.

While the data do not seem to contradict our theoretical predictions about reallocation between residential land and commercial land, we caution against overinterpretation. The quality of data on land quantities is so poor and their measurement is so fragmentary that future studies into this issue are warranted.

III. Commercial and residential real estate prices

In our paper we use prices of residential real estate as a proxy for those of commercial real estate for three main reasons. First, prices of commercial real estate are not as well measured as those of residential real estate. Second, the data history is much shorter for commercial real estate than for residential real estate. Third, the two series are highly correlated. Figure 3 displays the CoreLogic national house price index and the RCA-based national commercial real estate price index (both series come from the HAVER data analytics). Despite the short sample for commercial real estate prices, one can see clearly that the two series, residential and commercial real estate prices, are strongly correlated.

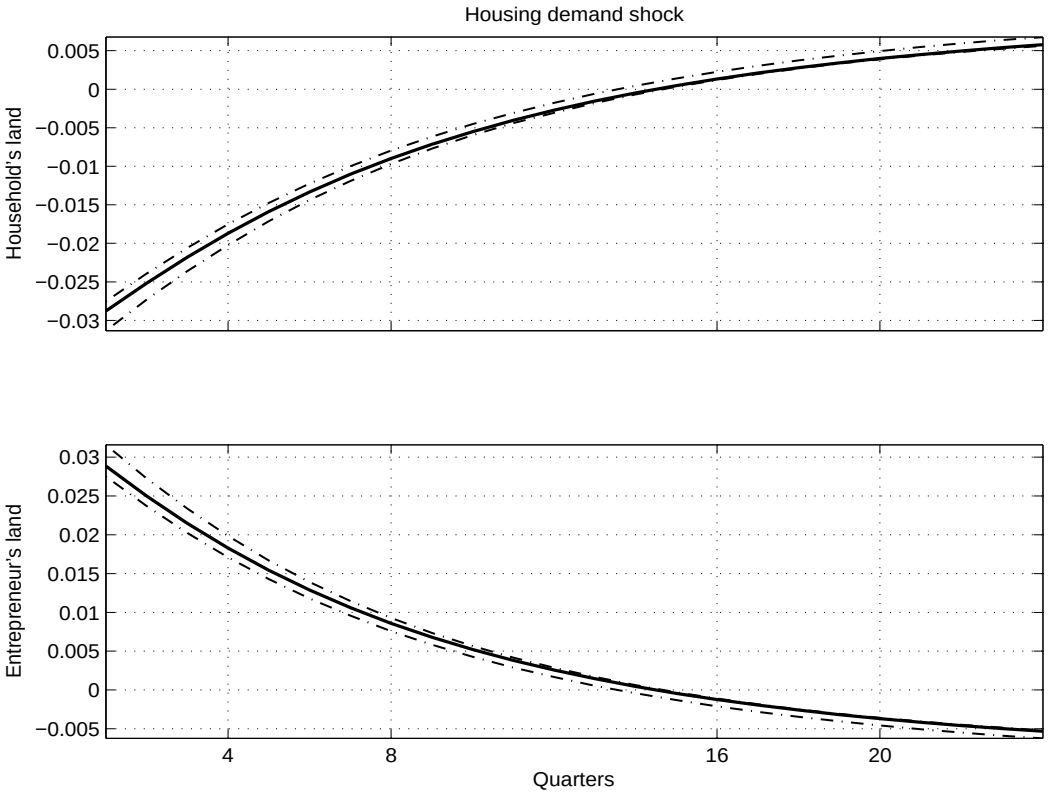

FIGURE 1. Impulse responses of land in each sector following a positive housing demand shock in the benchmark model.

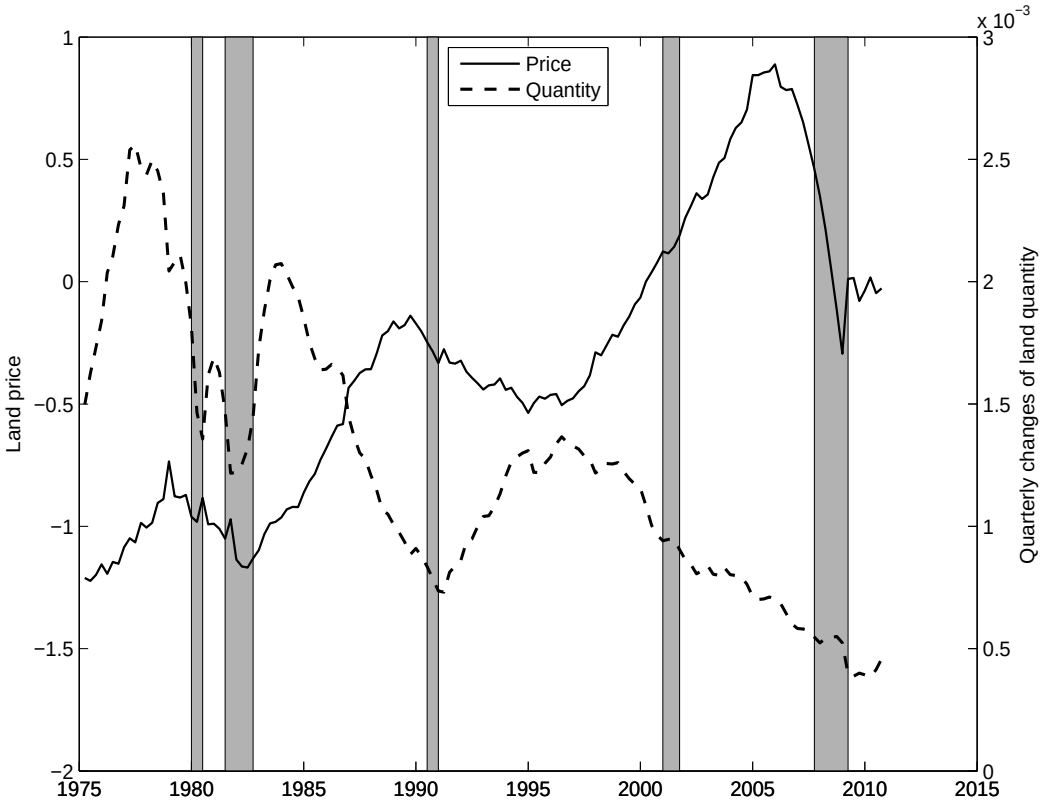

FIGURE 2. Log real land prices (on the left scale) and quarterly changes of land quantity (on the right scale). The shaded area marks NBER recession dates.

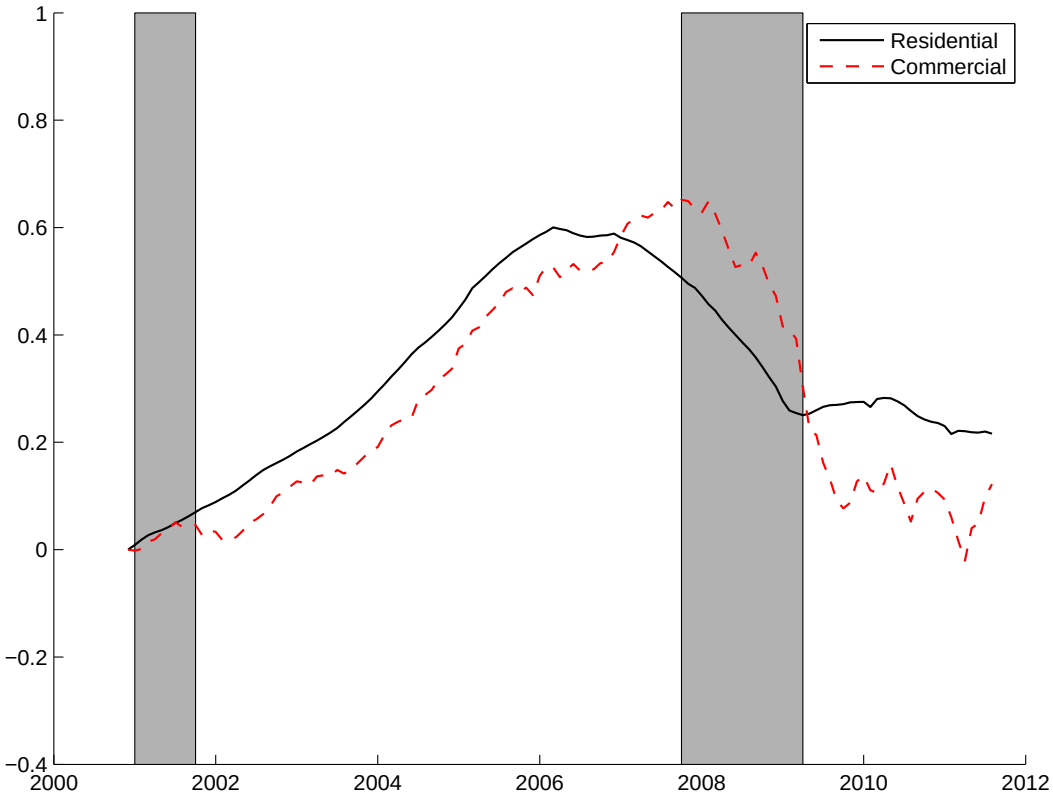

FIGURE 3. Log values of CoreLogic national house price index and the RCA-based national commercial real estate price index. The shaded bars mark the NBER-dated recessions.

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