Reconstructing the Great Recession*

Michele Boldrin
Washington University in St. Louis
Federal Reserve Bank of St Louis

Carlos Garriga
Federal Reserve Bank of St. Louis

Adrian Peralta-Alva
Federal Reserve Bank of St. Louis

Juan Sánchez
Federal Reserve Bank of St. Louis

February 15, 2011

Abstract

This paper uses a simple general equilibrium models with residential investment and input-output structure to illustrate the effects of demand shocks in the productive economy. A decline in the demand for homes generates a readjustment of the portfolio, and a decline in the demand of intermediate inputs, this depreoves the real side of the economy and generates a significant decline in employment and real activity. The effects are significant even when the shock is transitory.

Keywords: Residential investment, house prices
J.E.L. codes: E2, E6

*Preliminary and highly incomplete version. Work in progress. The authors are grateful to the stimulating discussions with Rody Manuelli. The views expressed herein do not necessarily reflect those of the Federal Reserve Bank of St. Louis nor those of the Federal Reserve System..

1 Introduction

This paper develops an aggregate capital accumulation model, with a residential investment sector and an input-output structure, to study the intertemporal general equilibrium effects of a negative shock on the demand for housing. We use this analytical framework to interpret the behavior of the US economy between 2007 and 2011 and reach a very straightforward conclusion: all that is "historically anomalous" in what has happened during the last five years can be accounted for by the equally anomalous shock to the demand for housing. As far as policy is concerned the basic implication of our research is straightforward: both the "lack of aggregate demand" and the "liquidity trap" explanations fail short of capturing the facts that, instead, the "It's the housing, stupid" explanaton does capture. The time and resources we have invested, since 2008, in trying to "stimulate" aggregate demand would have been better used had they been invested to revive the demand for housing, on the one hand, and to accomodate the downscaling of the construction sectors. More on these matters later in the paper, where we carry out a number of policy exercises; let us focus here on the basic intuition.

We build on the multi-sector general equilibrium analyses of Manuelli and Peralta-Alva (2011), and Garriga, Manuelli, and Peralta-Alva (2011) to obtain a model that takes into explicit account the input-output relations between the construction sector and the rest of the US economy. The model is purposefully very simplified as we intend to focus only on the impact that the permanent drop in the demand for housing has on aggregate employment and output because of the intersectorial linkages in the economy. In particular, we abstract from both the increase in the burden of debt that the drop in home prices brought about (which is the focus of Manuelli and Peralta Alva (2011)) and the reduction in credit activity it implied, two factors that are likely to have played (and still be playing) a major role in the overall process.

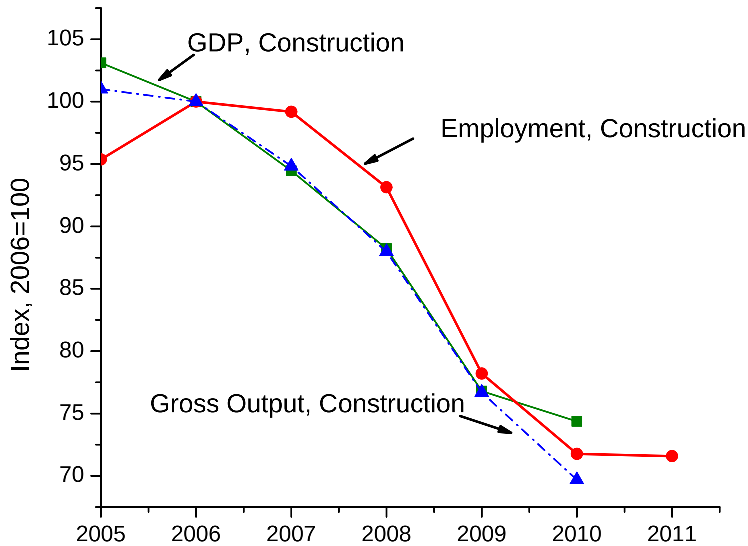
The bursting of a bubble in real estate values during 2006-2007 is commonly believed to be *the* key factor behind the U.S. great recession of 2007-2009 and the lackluster economic performance that followed. Why the bubble bursted, then and in that form, is not clear for the very simple reason that what created it in the first place is not clear either: it could have been monetary policy or the savings glut or the lack of proper regulation or the distorted incentives offered to homebuyers or, even, plain and simple mass hysteria. Be it as it may, we all agree that the bursting of the bubble did translate in a sudden drop in the demand for a specific asset in which American households had, until then, invested a substantial portion of their wealth: residential housing. We start from this, hopefully incontrovertible, fact and follow a sequence of straightforward economic links. The bubble in real estate values resulted in artificially high GDP levels and growth, driven by too high levels of output in the construction and housing sector and in all related activities. As the bubble burst these artificially high levels of GDP and growth collapsed, leaving the economy with an overhang of labor skills and equipment appropriate for housing related activities, but not easily transferable to other productive activities. This causal links, which are essentially due to the input-output structure of any advanced economy, operate in every environment, including those not subject to the market failures and price-adjustment frictions that standard monetary and fiscal policy tools can counteract. The relatively low depreciation of residential structures implies home values, the construction sector, and aggregate consumption and investment should take a long time to recover, and may actually never reach their peak levels (relative to trend) again. In technical terms, the burst of the real estate bubble might have substantially lowered potential output and created a substantial "displacement effect" for both labor and capital that may take quite a few quarters to fully absorb.

The rest of the paper is organized as follows. Section 2

2 Empirical Evidence

The construction industry went into recession one and a half years before the overall economy. Employment fell from 7.7 M in 2006:Q3 to 5.5M in 2011:Q1; it still has not emerged from the trough and the drop may well continue in the future. Figure 1 shows that employment, gross output, and GDP in the construction sector dropped about 30 percent during this period, with the largest year to year drop being between 2008 and 2009.

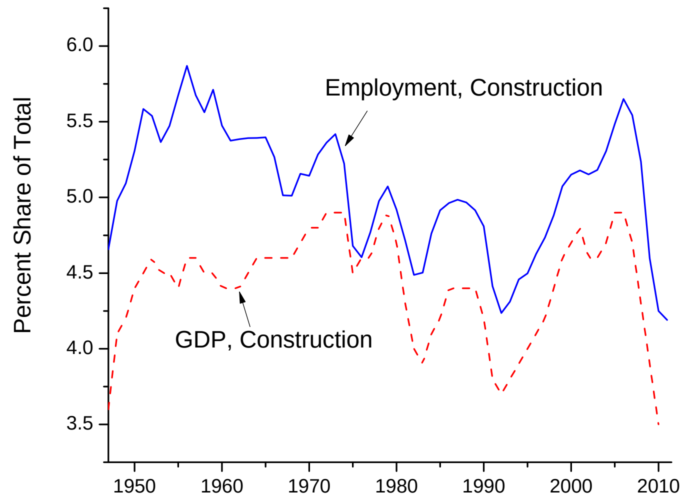
Figure 1



Source: Bureau of Economic Analysis / Haver Analytics. Employment is defined as All Employees: Construction (SA, Thous); GDP as Value Added: Construction (Mil.Chn.2005.$); Gross Output as Gross Output: Construction (Bil.$) deflated by Gross Output: Construction: Chain Price Index (2005=100).

Figure 2 displays the share of construction in total employment and total GDP. During the last recession the share of construction decreased by 1.2 and 1.5 percentage points in total GDP and total employment, respectively. The fact that the line for employment share is above the one for GDP share reflects the fact that Construction is relatively more labor intensive than the rest of the economy, which is just another way of saying that average labor productivity, in Construction, is below the economy-wide mean. The time series reported in Figure 2 also suggests that the distance from the average is procyclical, but this is scarcely relevant for our investigation.

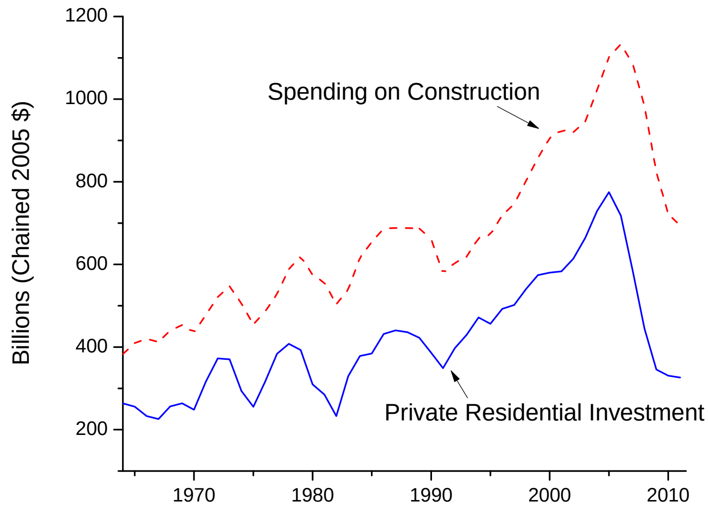
Figure 2



Source: Bureau of Economic Analysis. The share of GDP comes from the table Value Added by Industry as a Percentage of Gross Domestic Product. The share of construction in employment is caculated by dividing All Employees: Construction (SA, Thous) by All Employees: Total Nonfarm (SA, Thous).

Figure 3 displays private residential investment and total spending on construction. Both series show an abrupt decline between 2006 and 2010 while the extent of their growth between, roughly, 1990 and 2006 shows the extent to which the real eastate boom of those years was exceptional by historical standards.

Figure 3



Source: Private Residential Investment, BEA (Real Private Residential Investment (SAAR, Bil.Chn.2005$)). Spending on Construction, Census Bureau (Value of Construction Put in Place (SAAR, Mil.$)). Value spent on construction calculated from the Value of Construction Put in Place Survey.

2.1 Direct impact of Construction

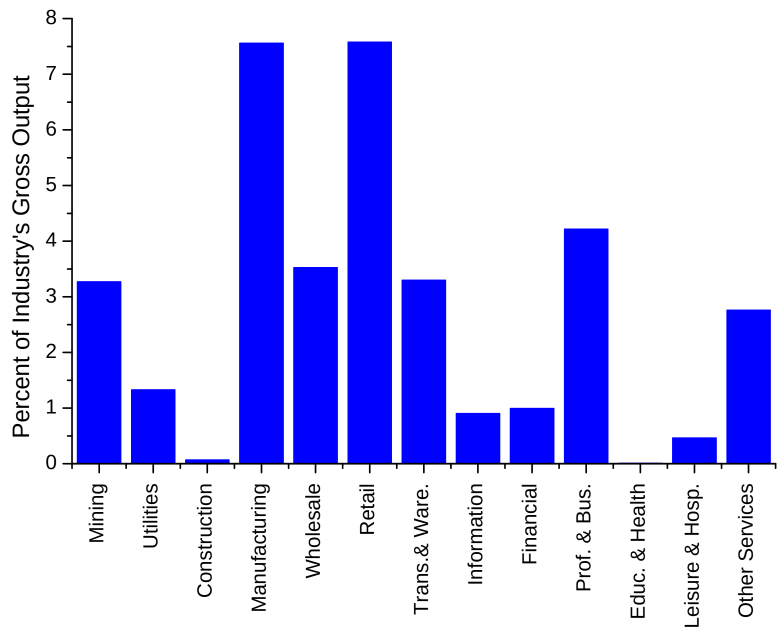
The Great Recession started in 2007:Q4 and it lasted until 2009:Q2. During this period total employment dropped abruptly, by roughly 8M jobs. Table 1 shows that the drop in construction's employment and value added accounts for about 27 and 22 percent of the total, respectively. Here the initial period is the average of the annual data for 2006 and 2007, and the final period is the year 2009. Larger shares are obtained if this computation is performed using the peak (2006:Q1) and the trough (2010:Q4) of the construction series.

Table 1: Direct impact of Construction in Employment and Income

	Peak	Trough	Change	
	2006-2007	2009	Thousands	%
Construction Employment, millions	7.7	6.0	-1.6	-21.5
Total Employment, millions	136.8	130.8	-6.1	-4.4
Share of Drop accounted for Construction, %		27.2		
Construction Income, billions	662.8	493.7	-169.1	-25.5
Total Income, billions	11,664	10,896	-768.7	-6.6
Share of Drop accounted for Construction, %		22.0		

Additional evidence suggests that the direct impact of the construction sector's drop on the overall economy may have been even larger. Figure 4 depicts the share of the gross output of each industry that is purchased by the construction industry as an intermediate input. These values are taken from the 2006 Use Matrix from the BEA Input-Output Tables. The simplest way of interpreting this data is to pretend we face a total collapse of the construction industry. In that case construction would buy nothing from other industries and the numbers in Figure 4 would represent the percentage drop in each industry's output after such an event. For instance, gross output in both Manufacturing and Retail would fall by roughly 7.6 percent. Next, the role of sectorial linkages is explored performing input-output counterfactuals.

Figure 4



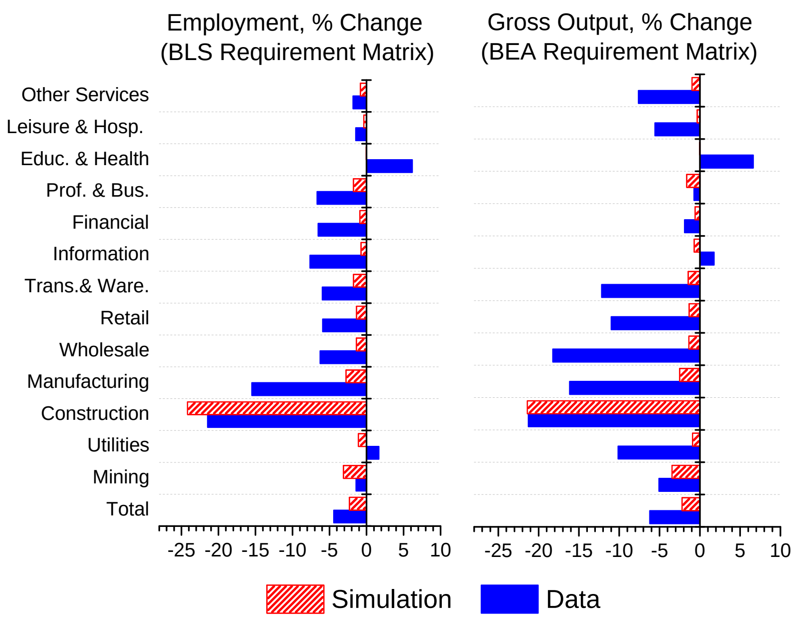
Source: 2006 Use Matrix from the BEA Input-Output Tables.

2.2 Intersectoral linkages, One-Shot Counterfactuals

The decline in the sectorial gross outputs implied by the input-output structure of the economy can be calculated using the 2006 requirement matrices from the BEA I-O tables and applying the actual decline of output in the Construction sector from 2006-2007 (average of these years) to 2009 (methodology is explained in more detail in the appendix). The same procedure is used to compute the impact on employment; here the BLS 2006 employment requirement matrix, in 2005 dollars, is used. The choice of the period we analyze is rather conservative: the share of sectorial outputs reduction mechanically explained by the drop in Construction could be substantially larger if the difference between the peak and trough of Construction output was used.

The blue area of Figure 5 shows the percent change of gross output and employment for 13 industries and for the total economy. While Construction's gross output declined by 21.28%, total gross output declined 6.22%. Employment in Construction decreased by roughly the same as gross output (21.47%), while total employment declined by 4.42% during the same period. The red stripped areas in Figure 5 display the part of the decline that Construction explains. For example, Construction explains a significant part of the gross output decline in Mining (specifically, 68% of its drop), while it explains little of the decline in Entertaintment, Recreation, Accomodation and Food Services (6 %). According to this exercise, Construction is capable of explaining 35.5% of the total decline in gross output, and 52.42% of the total decline in employment.

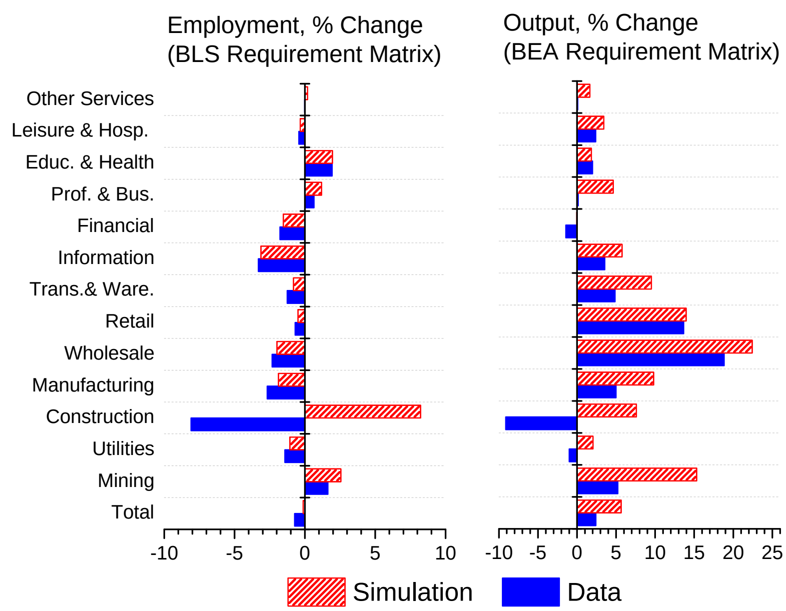
Figure 5



Source: Authors' calculations using 2006 BEA Commodity-by-Industry Total Requirement Table.

A similar exercise can be performed to measure how would the 2009-2010 recovery look like if Construction was growing at pre-recession levels (or at 2004 levels). For this exercise, again, the blue areas in Figure 6 display the actual change of gross output and employment in 13 industries and the total economy. While the data shows that gross output increased by 2.41% in this period, employment actually continued to decrease by 0.74%. If construction was growing at the pre-recession levels, total gross output would have increased by 5.64% in the 2009-2010 recovery and employment would have still decreased, but at the lower rate of 0.12% . The industries that would have grown the most in terms of gross output in this scenario are wholesale trade (44.4%), Mining (15.3%), and transportation and warehousing (9.51%).

Figure 6



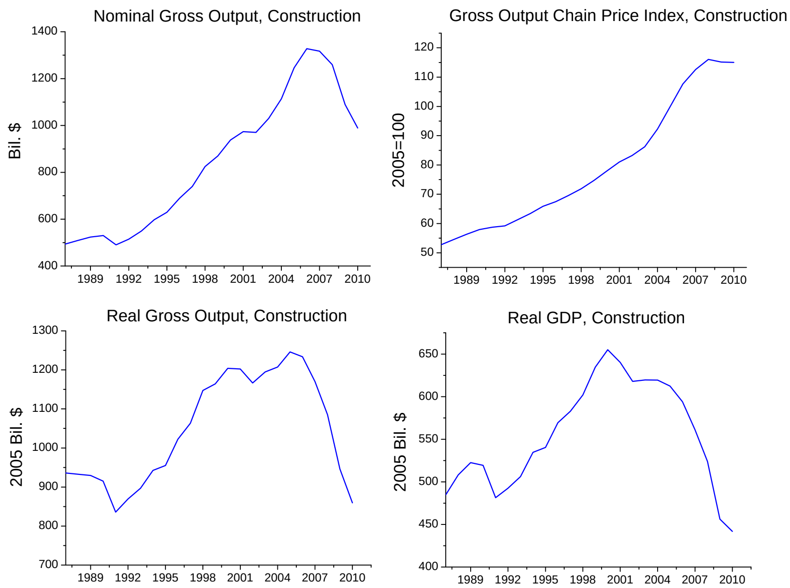
Source: Authors' calculations using 2009 BEA Commodity-by-Industry Total Requirement Table.

2.3 Intersectoral linkages, Dynamic Counterfactuals

The counterfactuals reported above are one-shot exercises in which we use peak to trough values to estimate some potential overall impact of the drop in construction. The recession cum recovery episode we are trying to study took place over a long period of time; it would therefore be interesting to try estimating the impact that the changes in construction activity, per se, had on the rest of the economy quarter after quarter. In fact, we find it interesting to ask the following question: leaving aside expectations and other linkages coming from households' and firms' intertemporal budget constraints and decision problems, what would have been the behavior of the aggregate US economy if the Construction sector had not existed at all? We try to answer this question for the period going from 1998 to 2010, for which the appropriate data are available (extension to cover 2011 as soon as data become available)[1].

Figure 1 depicts the relevant variables for the Construction industry; real gross output for Construction grew by 50% from 1991 to 2006, while value added grew by 23% over the same period. The reader may want to note that almost all the growth in nominal gross output of the Construction sector post 2001 is due to the raise in prices of houses, with very little increase in real output. Real value added of Construction, in fact, peaked long ago: in 2001.

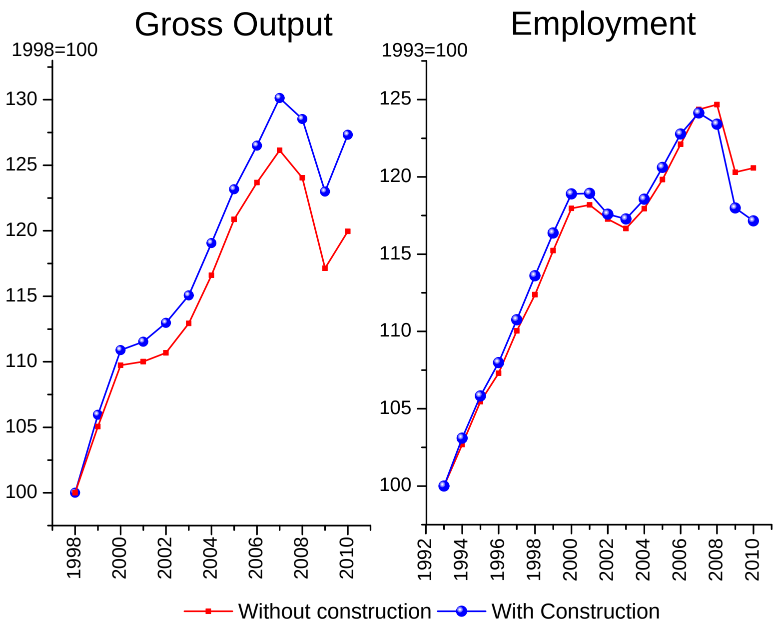
[1] Data for Construction are from the Bureau of Economic Analysis (BEA). Nominal gross output for Construction was deflated using the industry's gross output chain-type price index. Value added is already published in real terms by the BEA.



Source: BEA

The BEA's Industry-by-Commodity Total Requirement Tables and the BLS Employment Requirement Tables may be used, together with the aggregate data just reported, to build time series that remove Construction from the economy and take into account both the indirect and indirect effects this removal would have on other industries. For each year available in the BEA and BLS requirement tables, the real gross output for Construction was applied to the corresponding table to calculate the impact on total gross output and total employment the Construction industry had. Those values were then removed, together with the values of the Construction industry per se, from the aggregate gross output and value added of the US economy, year by year. Figure 2 displays these "adjusted" time series, normalized so that their start at 100 in year 1998.

Absent the Construction industry, total gross output would have experienced higher growth in the years from1998 to 2007 and a smaller drop during the most recent recession. Specifically, without the Construction industry, total gross output would have grown by 30.1%, from 1998 to 2007, and dropped by -5.5%, between 2007 to 2009. With the Construction industry, instead, total gross output variations turned out to be, respectively, 26.1% and -7.1% during those same periods. Employment shows a different dynamic: from 1993 to 2006, total employment with construction grew faster than without it. From 2006 to 2010, total employment without construction would have experienced a lower drop and higher levels of employment than with Construction. Specifically, while 7.7 million jobs were lost from 2006 to 2010 with Construction, only 3.7 million jobs would have been lost if the construction industry was excluded. In other words, this purely statistical exercise suggests that more than half the total drop in employment can be attributed, mechanically, to the collapse of constructions.



Source: Authors' calculations using BEA Total Requirement Tables and BLS Employment Requirement Tables for each year in the time series.

2.4 Input-Output Matrix, Coefficients

The following tables are constructed from the 2010 BEA's *Use* Input-Output Table. The use table shows the uses of commodities by intermediate and final users: rows present the commodities or products, and columns display the industries and final users that utilize them. The sum of the entries in a row is the output of that commodity. The columns show the products consumed by each industry and the three components of "value added"—compensation of employees, taxes on production and imports less subsidies, and gross operating surplus. Value added is the difference between an industry's output and the cost of its intermediate inputs, and total value added is equal to GDP.

Table 2 displays input-output values (which are originally in millions of dollars) as a fraction of the column industries' outputs. Construction gets most of its inputs from other industries (48.3% of its gross output) and only less than one percent from itself. This is also true for other industries since they most of their imputs from themselves (42.7% of their total gross output).

Table 2: Coefficients with Respect to Column Industries

Commodities /Industries	Construction	Other Industries
Construction	0.0009	0.0080
Other Industries	0.4831	0.4272
Compensation of employees	0.3623	0.3069
Taxes on production and imports, less subsidies	0.0072	0.0399
Gross operating surplus	0.1465	0.2179
Total	1.0000	1.0000

Table 3 displays input-output values as a share of the total commodities' output. While a significant part of construction's commodities are consumed by other industries (19% of construction's total commodity output) , the majority goes to private fixed investment (52.6%). Other industries' commodities, on the other hand are mostly consumed by other condustries and spent on personal consumption expenditures.

Table 3: Coefficients with Respect to Row Commodities

Comm. /Industries	Construction	Other Ind.	Personal Cons. Expend.	Private Fixed Invest.	Chg. in private Inv.	Exports of Goods & Services	Imports of Goods & Services	Gov. Cons. Expend.	Total
Construction	0.0009	0.1898	0.0000	0.5262	0.0000	0.0001	0.0000	0.2831	1.00
Other Ind.	0.0197	0.4131	0.4000	0.0675	0.0026	0.0642	-0.0844	0.1172	1.00

3 Model Economy

The input-output tables we used in the previous section are static and allow no substitutability whatsoever between productive factors in front of changes in either preferences or technology. While this may be a reasonable assumption in the very short run, i.e. on impact of a given shock or change in relative prices, it becomes much less reasonable when extended periods of time are considered. Furthermore, simulating the path of an economy over time by linking a sequence of static I-O matrices does not allow taking into account either the general equilibrium or the intertemporal effects of a given shock to initial conditions. The model we construct in this section allows both for richer dynamics and for a certain degree of substitution between productive inputs.

The closed economy we study consists of a unit measure of homogeneous households, two productive sectors (manufacturing and construction) and a government that is both taxing and spending but in an exogenous, lump-sum fashion. The two production sectors are connected through a simple, two by two, input-output matrix. All technologies exhibit constant returns to scale.The households produce the final housing services, which they consume, by combining structures (the output of the construction sector) and land, which is in finite and fixed supply. Households also consume (part of) the output of the manufacturing sector and supply labor time, receiving utility from leisure.

3.1 Households

The total population size, N_t, is normalized to one. Household preferences are defined by a time-separable utility function, $u(c_t, h_t; \theta_t) + \gamma v(1 - n_t)$, where c_t represents consumption goods, h_t represents housing services, n_t represents labor supplied in the market, and $\gamma > 0$ represents the relative weight of leisure in preferences. The preference parameter θ_t measures the relative desire for housing services versus consumption goods, which may change from one period to the next. The utility functions u and v satisfy the usual properties of monotonicity, concavity and differentiability. The sequence of utilities is discounted by the term $\beta \in (0, 1)$. Housing services are produced according to a technology, $H(s_t, l_t)$, which combines the stock of physical structures, s_t, and land, $l_t = 1$. The technology has constant returns to scale and satisfies $H_i' > 0$, $H_i'' < 0$, and $H_{ij}'' > 0$. Housing structures depreciate at a constant rate δ_s and the numeraire is, in each period, the spot price of the manufacturing good.

Formally, the representative consumer chooses non negative sequences $\{c_t, h_t, n_t, k_{t+1}, s_{t+1}, l_{t+1}\}_{t=0}^{\infty}$ to maximize

$$\max \textstyle\sum_{t=0}^{\infty} \beta^t [u(c_t, h_t; \theta_t) + \gamma v(1 - n_t)],$$

$$
\begin{aligned}
s.t. \qquad c_t + x_t^k + p_t^s x_t^s + p_t^l l_{t+1} &= w_t n_t + R_t k_t + p_t^l l_t + \pi_t^s \\
h_t &= H(s_t, l_t) && (1) \\
k_{t+1} &= x_t^k + (1-\delta_k) k_t, && (2) \\
s_{t+1} &= x_t^s + (1-\delta_s) s_t, && (3) \\
&\text{plus the transversality and the no-Ponzi-game conditions} && (4)
\end{aligned}
$$

where p_t^s is the price of infrastructures, p_t^l, is the land price, w_t, represents the wage rate and R_t, is the gross return on capital. To facilitate computing the rental rate for housing services, our specification allows land trading, l_t even if, in equilibrium, there is no trading in the land, which is owned by the representative household and inelastically supplied. Because the model is a complete markets model, and will be solved as a central planner problem by exploiting the well known implications of the second welfare theorem, we skip the derivation of the households' problem first order conditions here and proceed with the description of the technology.

3.2 Manufacturing sector

The production sectors incorporate the simplest input-output structure. To operate, each sector requires, among other things, also the output of itself and of the other sector as intermediate inputs. To capture this fact, we deviate from common practice and write all production functions in terms of gross (as opposed to net, i.e. value added) output, at least initially. Capital goods, which are produced in the manufacturing sector, must be distinguished from the intermediate inputs coming from the same sector as they last more than one period. In the baseline model capital goods are used in the manufacturing sector only while in one of the robustness exercises (yet) to be performed a putty-clay assumption on sector specific investment is eventually introduced and capital is assigned to both sectors.

Formally, let $m^{i,j}$ be the intermediate input produced by sector i and used by sector j. The manufacturing sector operates in a competitive market and uses the technolgy $Y_t = A_t^y F(k_t, n_t^y, m_t^{y,y}, m_t^{s,y})$ to produce its gross output

$$Y_t = c_t + x_t^k + m_t^{y,y} + m_t^{y,s}.$$

The production function $F(\cdot)$ is constant returns to scale and its exact functional form will be specified in the parametrization. For the moment assume that the technology satisfies the usual properies with respect to capital, labor, and an aggregator of intermediate inputs. In the baseline case the aggregator is Leontief , which is defined as $m_t^y(m_t^{y,y}, m_t^{s,y}) = \min\{\phi_t^{y,y} m_t^{y,y}, \phi_t^{s,y} m_t^{s,y}\}$, where $\phi_t^{i,j} \geq 0$. This formulation simply assumes that there is a (time-varying, at least in principle) matrix Φ_t of coefficients mapping the physical units of one good into the other when defining the efficient input requirements along the unitary isoquant; this matrix is given by

$$\Phi_t = \begin{bmatrix} \phi_t^{y,y} & \phi_t^{s,y} \\ \phi_t^{y,s} & \phi_t^{s,s} \end{bmatrix}.$$

The firm's optimization problem is, then:

$$
\begin{aligned}
\pi_t^y = \max_{k_t, n_t^y, m_t^{y,y}, m_t^{s,y}} & \; Y_t - w_t n_t^y - R_t k_t - m_t^{y,y} - p_t^s m_t^{s,y}, \qquad \forall t, \\
s.t. \qquad & Y_t = A_t^y F(k_t, n_t^y, m_t^y(m_t^{y,y}, m_t^{s,y})), \qquad \forall t,
\end{aligned}
$$

where the price of manufactuing's output is normalized to one. The constant returns to scale assumption implies zero equilibrium profits, $\pi_t^y = 0$, and marginal cost pricing for each input

$$R_t = A_t^y F_1(k_t, n_t^y, m_t^y(m_t^{y,y}, m_t^{s,y})), \tag{5}$$
$$w_t = A_t^y F_2(k_t, n_t^y, m_t^y(m_t^{y,y}, m_t^{s,y})), \tag{6}$$
$$1 = A_t^y F_3(k_t, n_t^y, m_t^y(m_t^{y,y}, m_t^{s,y})), \tag{7}$$
$$p_t^s = A_t^y F_4(k_t, n_t^y, m_t^y(m_t^{y,y}, m_t^{s,y})). \tag{8}$$

In the case of a Leontief aggregator the optimality conditions imply $\phi_t^{y,y} m_t^{y,y} = \phi_t^{s,y} m_t^{s,y}$, and the level of inputs moves with the scale of production.

3.3 Construction sector

The construction sector is also competitive: its net output are residential structures, purchased by the households, while its gross output includes also structures that are used as an intermediate input in both production sectors. In the baseline case, purely for simplicity, we assume this sector has a fixed stock of capital, hence its value added is split between the wages of labor and the rent accruing to the owner of the fixed capital stock (the representative households). Implicit in this formulation is a, somewhat extreme, assumption about factors' mobility from one sector to another: while labor can be moved freely, the stock of capital invested in the construction sector is completely immobile (either way) and variations in investment activity have an impact only on the manufacturing sector. This assumption will be relaxed - and the quantitative role inter-sectorial factor mobility plays in our model economy assessed - when carrying out the robustness' checks later in the paper. The technology for gross output

$$X_t^s = x_t^s + m_t^{s,y} + m_t^{s,s} = A_t^s G(n_t^s, m_t^s(m_t^{s,s}, m_t^{y,s}))$$

therefore exhibits decreasing returns to scale in labor and the intermediate input mix. Also here we assume the aggregator is Leontief, hence $m_t^s(m_t^{s,s}, m_t^{y,s}) = \min\{\phi_t^{s,s} m_t^{s,s}, \phi_t^{y,s} m_t^{y,s}\}$. The optimization problem of the representative firm is now

$$\pi_t^s = \max_{n_t^s, m_t^{s,s}, m_t^{y,s}} p_t^s X_t^s - w_t n_t^s - p_t^s m_t^{s,s} - m_t^{y,s}, \qquad \forall t,$$
$$s.t. \qquad X_t^s = A_t^s G(n_t^s, m_t^s(m_t^{s,s}, m_t^{y,s})), \qquad \forall t.$$

The first-order conditions are similar to those of the representative firm in the manufacturing sector and will not be repeated here. Notice that, because of the presence of a fixed stock of capital, firms' profits are not zero, in equilibrium, in this sector.

3.4 Competitive Equilibrium

Our notion of competitive equilibrium is completely standard, at least in this setting.

Competitive Equilibrium: *Given an exogenous sequence of shocks* $\{A_t^y, A_t^s, \phi_t^{i,j}, \theta_t,\}$, *a competitive equilibrium is a sequence of quantities* $\{c_t, x_t^k, x_t^s, l_t, n_t^y, n_t^s, m_t^{s,s}, m_t^{y,s}, m_t^{y,y}, m_t^{s,y}\}_{t=0}^{\infty}$, *and prices* $\{w_t, p_t^l, p_t^s, R_t\}_{t=0}^{\infty}$ *that satisfy*

1. *Given prices, the households solve their optimization problem by choosing those quantities,*

2. *Given prices, firms maximize profits by choosing those quantities,*

3. *Markets clear:*

(a) *Labor market* (w_t) :

$$n_t = n_t^y + n_t^s, \qquad \forall t,$$

(b) *Land market* (p_t^l) :

$$l_t = l_{t-1} = \bar{l}, \qquad \forall t,$$

(c) *Capital market* (R_t) :

$$R_t = A_t^y F_1(k_t, n_t^y, m_t^{y,y}, m_t^{s,y}), \qquad \forall t,$$

(d) *Manufactures market* $(p_t^c = 1)$:

$$c_t + x_t^k + m_t^{y,y} + m_t^{y,s} = A_t^y F(k_t, n_t^y, m_t^{y,y}, m_t^{s,y}), \qquad \forall t,$$

(e) S*tructures market* (p_t^s) :

$$x_t^s + m_t^{s,s} + m_t^{s,y} = A_t^s G(n_t^s, m_t^{s,s}, m_t^{y,s}), \qquad \forall t.$$

We have assumed complete markets from the outset, hence this equilibrium is efficient.

3.5 Social Planner Problem

The social planner problem associated to our market economy is also defined in a straightforward way. Find the quantity sequences $\{c_t, n_t^y, n_t^s, s_{t+1}, k_{t+1,} m_t^{y,y}, m_t^{s,y}, m_t^{s,s}, m_t^{y,s}\}_{t=0}^{\infty}$ that maximize

$$\max \textstyle\sum_{t=0}^{\infty} \beta^t [u(c_t, h_t; \theta_t) + \gamma v(1 - n_t^y - n_t^s,)],$$

$$\begin{aligned} s.t. \qquad c_t + x_t^k + m_t^{y,y} + m_t^{y,s} &= A_t^y F(k_t, n_t^y, m_t^{y,y}, m_t^{s,y}), \qquad \forall t, \\ x_t^s + m_t^{s,s} + m_t^{s,y} &= A_t^s G(n_t^s, m_t^{s,s}, m_t^{y,s}), \qquad \forall t, \\ k_{t+1} &= x_t^k + (1 - \delta_k) k_t, \qquad \forall t, \\ s_{t+1} &= x_t^s + (1 - \delta_s) s_t, \qquad \forall t, \\ h_t &= H(s_t, \bar{l}), \qquad \forall t, \\ s_0, k_0 &\geq 0, \end{aligned}$$

This is the dynamic programming problem we calibrate and simulate in the next Section.

4 Quantitative Analysis: Parameterization

The quantitative evaluation of the model requires specifying functional forms and parameter values. The choice of functional forms is relatively general. The utility function is consistent with unitary income elasticity,

$$u(c, h) = \frac{[\eta c^{-\rho} + (1 - \eta)\theta h^{-\rho}]^{-\frac{1-\sigma}{\rho}}}{1 - \sigma}.$$

where the parameter ρ pins down the elasticity of substitution between consumption and housing, the parameter σ represents the intertemporal elasticity of substitution, and η represents the relative importance of consumption. The production of housing services is also given by a CES specification,

$$h = H(s, l) = z_h [\epsilon s^{-\gamma} + (1 - \epsilon) \bar{l}^{-\gamma}]^{-\frac{1}{\gamma}}.$$

where the parameter γ determines the elasticity between structures and land, z_h represents a transformation factor between the stocks and the flow, and ϵ represents the share of structures. The production of consumption goods uses a Cobb-Douglas technology

$$A^y F(k, n^y) = A^y k^\alpha (n^y)^{1-\alpha}.$$

The technology used in the construction sector has diminishing returns $A_t^s (n_t^s)^\phi$ where $\phi \in [0,1)$

The model parameters are set to match long-run averages of their data counterparts between 1952-2000. The implied parameter values are relatively robust to the choice of the sample period; however, during the housing boom, some of the usual ratios and long-run averages departed significantly from their long established historical averages or trends. The model's targets, therefore, need to be adjusted to be consistent with the more recent data counter part [This is to be done more carefully in final version]. Further, the notion of GDP we like to use in our analysis only refers to the private sector, i.e. Total GDP minus government consumption and investment expenditures. In the U.S. National Income and Product Accounts (NIPA) housing services are part of consumption expenditures. During the sample period this variable averaged 9 percent of GDP and the adjusted non-housing consumption was 68.5 percent of GDP.

The model economy has three types of capital: residential structures, land, and machinery used in the manufacturing sector. The U.S. Flow of Funds provides market value estimates of the stock of residential real estate for households and for the non-financial non-corporate sector (essentially owners of residential real estate who lease it). The Flow of Funds also estimates the value of residential structures, but it does not provide the market value of land. This value can be computed as a residual.[2] In the sample period the value of structures and land amounts to 103.5 percent and 60.2 percent of GDP respectively. Capital in the non-housing sector is computed as a residual from the sum of non-financial assets of the household, corporate, non-financial non-corporate, and the financial sector minus the value of residential land and structures.[3] Between 1952 and 1997, the stock of capital (non-housing) is two times non-housing output.

The Cobb-Douglas specification for the production of goods and capital implies that the labor share is pinned down by $1-\alpha$. In the model both sector use labor, as a result, the labor share $1-\alpha$ should correspond to all forms of labor compensation in the NIPA relative to non-housing GDP.The adjusted labor share of non-housing GDP averaged 75 percent.

Discuss the calibration of profits in the construction sector (To be done).

The results of the calibration is summarized in this table

Calibration

	Data	**Model**
Employment:	0.33	0.33
% Goods sector:	0.91	0.97
Consumption Share:	68.0	74.5
Rental Share :	9.0	9.43
Investment Share:	19.8	16.1
% Capital:	70.0	79.3
Housing/capital:	0.5	0.66
House Value/GDP:	1.5	1.50
Capital/GDP:	2.2	2.28

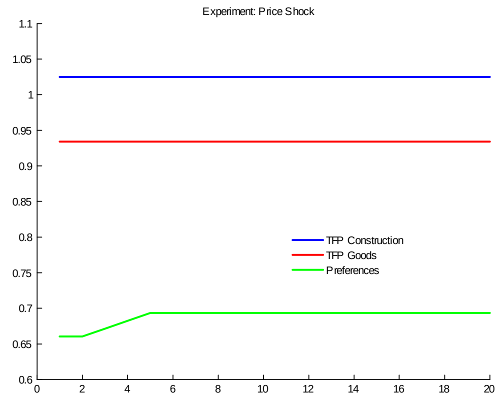
[2] The obtained estimates are consistent with the values obtained by Davis and Heathcote (2007).

[3] The first three come from the balance sheets of the respective sectors, as reported by the Flow of Funds, while data for the financial sector is taken from the wealth tables of the United Sates computed by the Bureau of Economic analysis.

4.1 Dynamics (Permanent shock)

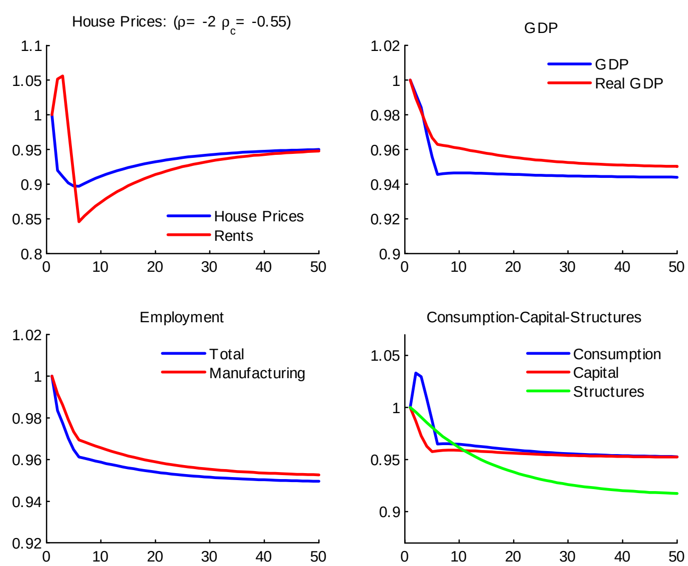
The baseline experiment assumes a 5 percent shock to the share of consumption that increases from 0.66 to 0.70 percent. The path of preferences is announced in period 0 and it is completely unanticipated. Figure 3 summarizes the path for the preference shock and the productivity levels in each sector (manufacturing and construction).

Figure 3: Permanent Taste shock (5%)



The baseline economy has a elasticity between structures and land of 0.33. The preference shock implies a 10 percent decline in house prices. Prices decline despite the short-run increase in rents. This can be explain by the boom in consumption that drive rents up, but the future decline drive prices down on impact. The model suggests that a short-run dynamics can be very different than the long-run effects. For example, house prices decline in the initial periods around 11 percent, but in the long-run prices only fall by 5 percent. The quantitative impact on output depends on whether is measured at initial prices, or current prices (relative prices substantially move). A 10 percent decline in house prices can be consistent with output declines that range between 4 to 6 percent.

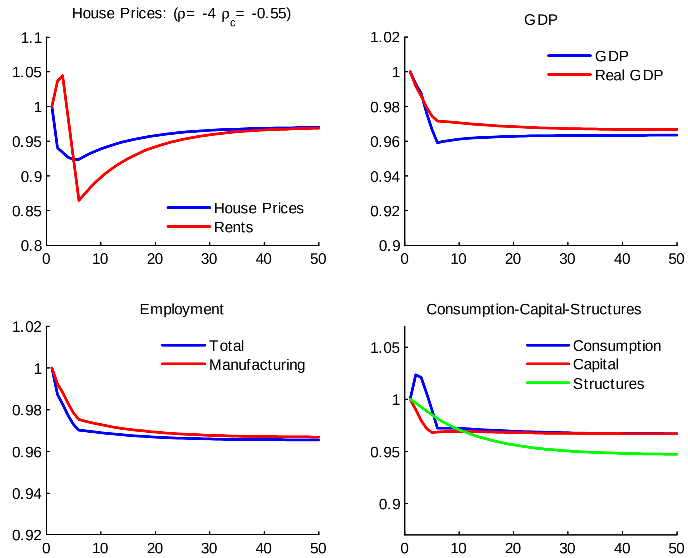
Elasticity $\varepsilon_{sl} = 0.33$



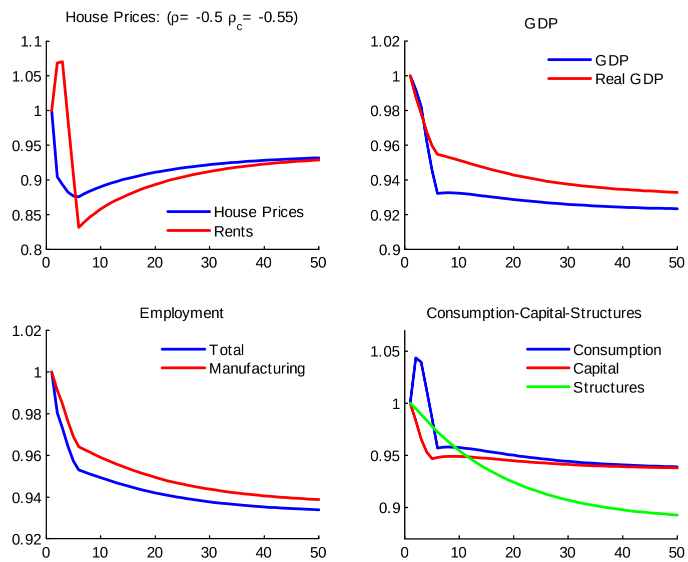
The complementarity between consumption and housing goods drives long-run total expenditure down, and the optimal strategy is to consume more leisure. With the existing calibration total employment declines 4 percent. The declines in output and employment are permanent and the adjustment last several years. This is due to the fact that the depreciation rate os structures is very low. It takes a significant amount of time for the economy to bouce back to the pre-crises levels in terms of output and employment.

Changes in the elasticity between structures and land have significant effects in the dynamics of output and house prices.

Elasticity $\varepsilon_{sl} = 0.20$



Elasticity $\varepsilon_{sl} = 0.667$

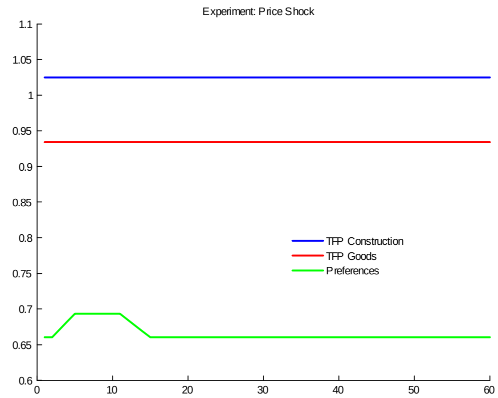


With a lower elasticity of substitution, the decline in the optimal level of structures is much smaller than in the baseline case. As a result short-run house prices only decline 5 percent. The impact on aggregate activity still significant (2 percent), but lower in the baseline. The model also predicts that in areas with high elasticity between structures and land, the decline in the construction sector has a more severe impact in aggregate activity and house prices.

4.2 Dynamics (Transitory Shock)

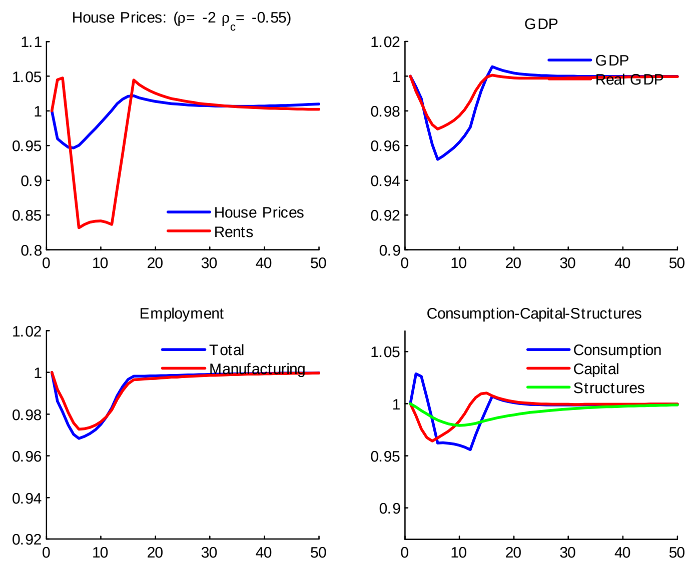
Transitory shocks to preferences are also considered. The next experiment assumes that the shock only lasts a few periods, and then is reverted back to the initial level. The productivity level of different sectors remains at the steady state levels.

Figure 3: Transitory Taste shock (5%)

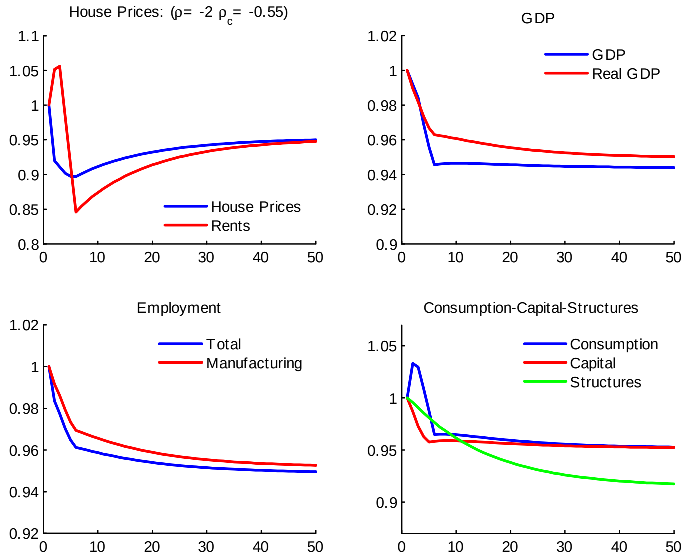


The short-run dynamics are similar, but the magnitudes are not so large. The transitory shock generates a decline in the price of homes of 5 percent instead of 10 percent, and the effects in aggregate activity are smaller. However, the effects are still significant and relatively persistent.

Transitory Demand Shock



Permanent Demand Shock



5 Conclusions

This paper uses a simple general equilibrium models with residential investment to account for the recent US deep recession and relatively slow recovery. The model can predict large negative effects on quantities (aggretate output and employment, in particular) as a result of a decline in house prices and a reduction in the demand for residential structures.

[TO BE COMPLETED]

6 References

Bernanke, B. (2010), "Monetary Policy and the Housing Bubble," Presented at the Annual Meeting of the American Economic Association, January 3.

Chambers M., C. Garriga, and D.E. Schlagenhauf (2009a), "Accounting for Changes in the Homeownership Rate", *International Economic Review*, 2009.

Davis, M. and J. Heathcote (2006), "The Price and Quantity of Residential Land in the United States," Mimeo Georgetown University.

Fisher, J. D. M., and S. Quayyum (2006), "The Great Turn-of the Century Housing Boom," *Economic Perspectives*, Federal Reserve Bank of Chicago, 29-44.

Green, R.K., S. Malpezzi, and S.K. Mayo, (2005), "Metropolitan-Specific Estimates of the Price Elasticity of Supply of Housing, and Their Sources," *American Economic Review*, 95(2), 334-339.

Kiyoyaki, N., A. Michaelides, and K. Nikolov (2007), "Winners and Losers in the Housing Market," Working Paper, Princeton University.

Mankiw, N.G., D.N. Weil (1989), "The Baby Boom, the Baby Bust, and the Housing Market, " *Regional Science and Urban Economics* 19: 235–258.

Martin, R.F. (2005), "The Baby Boom: Predictability in House Prices and Interest Rates," IFDP 847, Board of Governors.

7 Appendix

BEA Input-Output Exercises: To calculate the impact of Construction to total gross output: Data was obtained from the BEA. Gross output consists of the goods and services produced by an industry; it is measured by summing the value of the industry's sales or receipts, other operating income, commodity taxes, and inventory change. Gross output for each industry was deflated by its corresponding price index. Industries are defined according to the 2002 NAICS 2-digit classification system.

To calculate the total effect of the decline in construction on total output, the 2006 Commodity-by-Industry Total Requirements Table was used. This table shows output required, directly and indirectly, by each industry to deliver a dollar of final demand of a commodity. Call this matrix G. Vector D is composed of the individual drops in gross output in each industry i from 2006-2007 (average of these years) to 2009. Therefore, $G * D$ will give a vector of simulated gross output changes for each industry i and can then be used to analyze how much of the change in each industry is explained by the drop in Construction. Call this vector of individual industry drops F. Analogously to the direct effect, the total effect is given by:

$$Total\ Effect_{total\ output} = \frac{\sum^{15}(F_i)}{Initial\ Total\ Gross\ Output}$$

Changes in employment can be simulated using the Bureau of Labor Statistics Employment Requirement Tables. For this, the Real (2005 dollar value) tables were used.

BLS Input-Output Exercises: To calculate the impact of Construction to total employment: Data was obtained from the BLS. Specifically, for the effect of Construction in the last recession, the 2006 employment requirement matrix in real 2005 dollars was used. To calculate the effect that a higher growth in construction would have on the current recovery, the 2009 employment requirement matrix was used. These tables are derived from input-output data, and show in each column the employment generated directly and indirectly across all industries by a million dollars production of a given industry's primary product. The data can give an indication of the relative impact of different industries' primary production. The impact of construction in195 industries (the rows in the matrix) were grouped according to their 2007 NAICS code into the same major industry groups that are used in the Interactive BEA Input-Output Tables.