

ESSAYS ON HOUSING, UNEMPLOYMENT AND MONETARY POLICY

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ABSTRACT

In this dissertation, I study the interconnections between the housing market and labor market, and the link between monetary policy and housing market activity.

In the first chapter, I focus on the interplay between the housing and labor market. To do so, I construct a model of search and bargaining across two different markets: the labor market and the housing market. The model highlights that housing prices and frictions in the housing market have a profound impact on labor market activity through the desire of workers to eventually purchase a home, the "American Dream." The model also reveals that labor market frictions can impact housing market activity. I also perform a calibration exercise to evaluate economic activity in general equilibrium. I find that frictions in the housing market generate strong negative external effects on the labor market. More specifically, a tighter housing market is associated with higher unemployment rates and less job creation. Consequently, my findings suggest that policymakers should be very careful in implementing policies targeted towards housing – housing markets are likely to generate significant external effects to other sectors of the economy, especially the labor market.

To study the effects of monetary policy on housing market activity I develop an overlapping generations model in which housing is traded across generations of individuals. Incomplete information leads to a transactions role for money so that monetary policy can be effectively studied. Moreover, individuals face liquidity risk which interferes with their ability to accumulate housing wealth. Contrary to the existing literature, I demonstrate that it is important to disaggregate fixed investment between the residential and non-residential sectors. In particular, I find the effects of monetary policy are asymmetric across the components of the overall capital stock. I conclude this chapter with a policy experiment studying how optimal monetary policy depends on housing market fundamentals. In response to adverse supply conditions in the housing sector, monetary policy should be more aggressive in order to promote residential investment and the housing stock. However, monetary policy should be conservative in order to limit exposure to risk if fundamentals favor housing demand.

The third chapter is an empirical look at the relationship between monetary policy and housing market activity. I analyze and quantify the effects of monetary policy on residential investment, housing starts,

new private housing permits and new single family houses sold. To conduct the analysis I estimate a vector autoregression model (VAR) where the monetary policy shock is identified using sign restrictions. No restrictions are imposed on the variables of interest, however, in response to a monetary policy shock I impose sign restrictions on the impulse responses of price, output, reserves and the federal funds rate. I find that a contractionary monetary policy shock reduces housing market activity for up to a year after the shock. Interestingly, 2 to 3 years after the economy contracts, activity in the housing sector reverses course. The findings suggest that once the economy contracts the Federal Reserve Bank reverses course by lowering the federal funds rate, and this policy reversal stimulates housing market activity.

DEDICATION

This dissertation is dedicated to my family and friends. I have a special feeling of gratitude to my loving mother, Willie Jean Green, who taught me the value of hard work. I give special thanks to my daughter Nykeria for keeping me motivated and to my brother Patrick for his support and sacrifice over the years.

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Chapter 1: Housing and Unemployment: The Search for the American Dream

1 Introduction

The recent financial crisis in the United States demonstrates that there are significant linkages between housing market conditions and labor market performance. Therefore, it is critically important to start taking a look at the deep connections between labor market and housing market activity. For example, how does labor market activity affect housing market behavior? Alternatively, how do housing market conditions impact the performance of the labor market? These are important, but complicated questions – activity in each sector feeds into the other sector. Consequently, ignoring such connections almost certainly would lead to ineffective policymaking. Yet – that appears to be the modus operandi in policy discussions – for example, current policy debates aimed at promoting housing market activity virtually omit any discussion of the role of labor market conditions such as wages or the duration of unemployment spells.

In addition to ignoring the linkages between both markets, much existing research ignores that there are significant information frictions within each market. To begin, workers generally engage in a relatively long period of job search before finding employment. In 2005, workers were unemployed for an average of 18.5 weeks. Therefore, even in a strong labor market, workers generally needed around 4.5 months to locate a successful job match. By comparison, in 2011, the average duration of unemployment was much higher – nearly 10 months. It also takes a relatively long amount of time to sell a home – a process that has become noticeably more difficult since the housing recession began. In 2005, only 22% of homes were vacant for more than 6 months. By comparison, in the fourth quarter of 2011, around 35% were vacant – nearly 60% more. In particular, Genesove and Han (2011) using data from the National Association of Realtors find that seller time significantly depends on the level of market demand. Given these observations of pronounced delay, there are clearly appreciable transactions costs in each market. It takes time to find a job. It also takes time to find a home-buyer. Consequently, the standard Walrasian market-clearing paradigm does not apply to either market. Since the Walrasian clearing mechanism does not apply, the standard price-taking mechanism is not appropriate to study the determination of wages or home prices. Moreover, the effects of policy depend on the time involved in the search process and the price-determination mechanism in each market. Notably,

Henley (1998) observes: “UK economists have been concerned for some time that the housing and labour markets may not operate together in a frictionless manner.”

How does activity in the labor market and housing market depend on the information frictions and non-competitive price determination in each market? Moreover, how should policymakers account for the connections between housing and labor market conditions? Finally, is it possible to account for the level of housing price appreciation witnessed during the recent housing boom in a general equilibrium model with search frictions and bargaining?

To adequately address these important concerns, a model that clearly analyzes market fundamentals with *endogenous* transactions costs is required. Consequently, the objective of this paper is to develop a general equilibrium, search-theoretic model that is able to address the significant connections between housing and labor market outcomes. In my framework, unemployed individuals spend time searching to find job vacancies. Once a worker contacts a vacancy, workers engage in bargaining over their wage rate. Upon earning labor market income, workers can begin searching for a home to purchase so that they can enjoy the benefits of home ownership. Thus, my model introduces an important connection between housing market conditions and labor market activity – *the value of finding a job extends beyond labor income, it also includes the discounted benefit of access to housing*. In this manner, I am able to demonstrate that *housing market conditions* are an important component of *labor market incentives*. Therefore, policies designed to affect home ownership such as the mortgage interest deduction are highly likely to affect labor market activity. By comparison, adverse housing market conditions (i.e., higher property taxes or rationing of mortgage credit) would also generate an external effect beyond the housing market.

I turn to determination of housing market activity. While demand for housing comes into the market as workers find jobs, the supply of homes is also tied to demographic patterns. That is, the lifecycle plays an important role in the demand and supply of housing. Alternatively, turnover in the labor market also affects housing supply.¹ Upon finding a suitable home, the buyer and seller bargain over housing prices. A worker’s surplus from home ownership depends on wages, the expected length of time that they will remain in the home, and the utility from home ownership. The seller’s surplus from finding a buyer depends on the sale price of the home and the amount of time it would take to find an alternative buyer. Thus, labor market conditions through wages and labor force participation rates may also affect prices and tightness in

¹Ai et. al. (2003) study the lifecycle components of housing demand.

the housing market. Therefore, policies targeted towards the labor market would also transmit to housing market activity.

My work contributes to a growing literature that emphasizes the connections between housing and labor markets. To begin, Coulson and Fisher (2009) study the consequences of home ownership for unemployment rates.² In their empirical analysis, they find that homeowners have a lower incidence of unemployment, but also receive lower wages than renters. By comparison, Cunningham and Reed (2012a) study the consequences of housing equity for wages among homeowners in the American Housing Survey. In particular, they find that individuals in a negative equity position earn wages that are almost 7% lower than other homeowners. In addition, Cunningham and Reed (2012b) demonstrate that workers' equity positions affect wages and the extent of involuntary unemployment in a model with moral hazard in the labor market.

As I emphasize, Coulson and Fisher argue that the Walrasian price-taking mechanism is inappropriate for wage determination in the labor market. If wages are determined through bargaining, higher levels of home ownership are associated with lower unemployment rates. However, Coulson and Fisher do not include a real estate market in their analysis. Consequently, in contrast to my setting, they are unable to look at the impact of labor market activity on housing conditions. Moreover, in contrast to my framework, the desire to purchase a home cannot influence worker incentives or labor market performance. That is, in contrast to Cunningham and Reed (2012a,b) I study how housing prices affect wages among individuals who do *not* own a home.³ Yet, housing prices affect labor market outcomes. Therefore, I pay little attention to “wealth effects” from homeownership in my framework. Instead, it is the desire of individuals to eventually purchase a home (the “American Dream”) that affects workers' incentives.

In other recent work, Head and Lloyd-Ellis (2012) study an economy with two sectors: the housing sector and the labor market. Both sectors are plagued by search frictions. However, Head and Lloyd-Ellis assume that workers are price-takers in the labor market. Again, by ignoring the desire for homeownership in workers' incentives, externalities from the housing sector are omitted. Nevertheless, I contend that the “American Dream” leads to a crucial role for housing market activity to affect labor market outcomes.

The paper is organized as follows. Section 2 describes the physical environment. The economy is made up of two markets: a housing market and a labor market. Section 3 describes the matching process and

²See also Dohmen (2005).

³Interestingly, Campbell and Cocco (2007) observe that housing prices affect consumption levels among *both* homeowners and renters in the United Kingdom.

introduces the bellman equations that guide my analysis. Within both sectors of the economy, matches are formed according to a matching technology. Section 4 derives the steady-state analysis for a partial equilibrium model with exogenous housing prices.⁴ Section 5 formulates the steady-state properties for a partial equilibrium model with exogenous wages. Section 6 introduces a general equilibrium model with wages and housing prices endogenously determined. I calibrate the model and present the results of my calibration analysis. In Section 7 I conclude and discuss policy implications.

2 Environment

I construct a continuous time dual search economy. There are two decentralized markets, a housing market and a labor market. Due to frictions in each market, time is required until matches in each sector of the economy occur. The economy is populated by risk-neutral workers and firms who discount the future at rate $\rho > 0$. At the beginning of each period, new workers are born at a constant rate of $\eta > 0$. Workers do not differ in terms of skills or preferences. Moreover, the productivity of each job match is the same. As I explain below, once a worker-firm match is formed the match produces a non-storable consumption good. In addition to labor market activity, there is an active housing market. In this market, a stock of homes is traded across generations of individuals. Once individuals reach old age, they retire, sell their homes, and exit the economy. Houses do not depreciate.

The Labor Market

As a result of frictions in the labor market, it takes time for firms to contact unemployed workers. Likewise, workers spend time searching, collecting information, and applying for jobs. I assume that contact between the worker and firm is random. More specifically, a random subset of unemployed workers and vacant jobs are brought together via a matching technology. Unemployed workers meet job vacancies with arrival rate $\alpha > 0$. By comparison, vacancies contact unemployed workers with arrival rate $\beta > 0$. Once a match is formed, the worker and firm bargain bilaterally over wages. Job destruction does not occur.

⁴In this manner, our work follows the approach of Laing, Palivos, and Wang (1995) who study human capital investment in the presence of search frictions in the labor market. Taking the level of human capital accumulation as given, they show how labor market frictions and wages interact with an exogenous level of schooling to impact steady-state activity. After this benchmark setting, they endogenize the level of schooling. We study interactions between two different markets: the labor market and the housing market. Consequently, we begin by studying activity in each market taking the price in the other sector as given. We conclude with analysis in general equilibrium.

Instead, matches in the labor market remain in tact until the worker reaches old age and retires from the economy.⁵

The Housing Market

Similar to the labor market, finding a match within the housing market takes time. In addition to the time spent searching, home buyers view and inspect potential homes. It also takes time for a seller to contact a potential home buyer. In contrast to the labor market, I abstract from costs of posting housing vacancies. Consequently, buyers and sellers are randomly matched, and this match is generated from a realization of the matching function in the housing market. Potential buyers meet potential sellers with arrival rate $\lambda > 0$. Sellers make contact with buyers at a rate of $\sigma > 0$. Provided that a buyer-seller meeting takes place, the price of the home is determined by Nash bargaining. As the stock of homes does not depreciate and the size of the population is constant, residential construction is not necessary.

2.1 Firms

There is a continuum of firms in the economy at any point in time. Each firm has access to a constant returns to scale production technology in which labor is the only input. To be specific, the productivity of each match is equal to y each period. Net revenue over time is income in excess of wages (w), $y - w$.

2.2 Workers

Upon entering the economy, workers immediately begin searching for job opportunities. Each worker has the same level of ability in terms of labor productivity and there is no disutility from labor effort. After gaining employment, a worker is eligible to participate in the housing market and search for a home to purchase. In this manner, my model reflects the strong degree of labor market attachment that is generally required in order to get access to mortgage credit.⁶

Owning a home not only serves as an investment, but it also provides utility in terms of psychological satisfaction – one of the central tenets of the housing literature. The utility value of homeownership is

⁵As job separation does not occur until the worker exits the labor market, wages are independent of wealth effects from housing prices. In contrast, Cunningham and Reed (2012b) study the implications of housing equity for worker incentives and labor market activity but they do not model the process by which individuals become homeowners.

⁶By comparison, unemployed workers can purchase homes in the study of housing and mobility by Head and Lloyd-Ellis (2012).

represented by z . There are a number of factors which contribute to the utility from owning a home. For example, individuals are likely to develop social capital through interactions in their neighborhood. In addition, individuals often cite the emotional stability resulting from homeownership. They also have access to local public goods. Such factors do not appear in models of labor market activity. Interestingly, as I show below, the value of home ownership can have a significant impact on labor market activity through workers' incentives to find a job and eventually gain access to the housing market.

With flow probability ω , workers age, retire from the labor market, and no longer receive utility from owning a home. One can interpret that ω represents a type of negative health shock in which individuals become physically unable to work and care for their homes. In this manner, my framework captures the lifecycle component of housing demand. As a result, buyers in the housing market are composed of young workers who have found stable employment. Sellers in the housing market are determined by the number of individuals seeking to sell their existing homes.

3 Matching and Bellman Equations

In this section, I further elaborate on the matching process within both markets. I begin with the labor market and follow with the housing market. As I describe below, the total number of matches in each market over time results from a matching technology in each segment of the economy.

3.1 Labor Market Matching

Unemployed workers meet vacancies at the rate αU , where U represents the number of unemployed workers. Additionally, vacancies meet unemployed workers at the rate βV , where V signifies the measure of vacancies. The total number of matches on each side of the market must be the same. Therefore:

$$\alpha U = \beta V \tag{1}$$

The total number of matches over time is governed by the matching function in the labor market, $m_o M(U, V)$. The parameter m_o reflects the productivity of matching in the market. As a result, I have:

$$\alpha U = m_o M(U, V) = \beta V \quad (2)$$

Assumption 1. The matching function, $M(U, V)$, is continuous, strictly increasing, concave in each argument, twice differentiable and exhibits constant returns to scale. Following the literature, I assume it has the Cobb-Douglas form.

3.2 Housing Market Matching

Due to imperfect information, buyers and sellers are both required to search. As workers discount the future, the delay required to find a buyer or seller is costly. Buyers make contact with sellers at the rate λ_o . Likewise, sellers find home buyers at the rate σ . As E_0 indicates the number of home buyers and R represents the measure of retired individuals in the economy, matches on both sides of the market must be equal:

$$\lambda E_0 = \sigma R \quad (3)$$

As agents confront search frictions in the housing market, I assume the matching rate is determined by a Poisson process with parameter h_o representing the ease or difficulty of creating matches. The matching function, $h_o H(E_0, R)$, has the same properties as the matching function in the labor market:

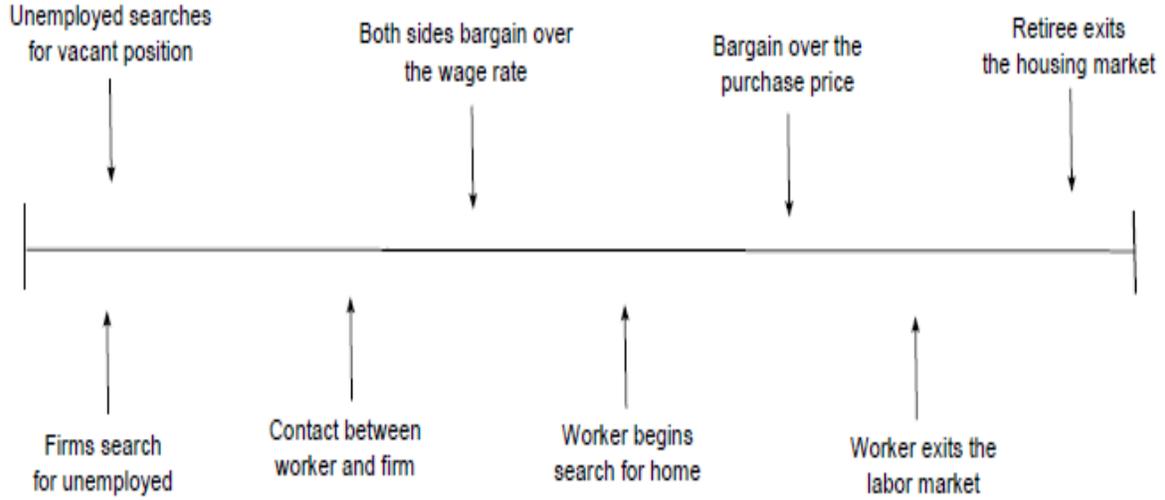
$$\lambda E_0 = h_o H(E_0, R) = \sigma R \quad (4)$$

Assumption 2. The matching technology, $H(E_0, R)$, has the same properties as the matching technology, $M(U, V)$.

3.3 Bellman Equations

Over time, workers transition through four different states. Upon birth, workers are unemployed. They remain so until they find a match with a vacancy. After finding a job, workers become eligible to buy a home.⁷ After their working careers, workers sell their homes and exit the economy. Vacancies are either filled or unfilled. The timeline of actions for each individual is presented in the following timeline:

⁷For tractability, rental costs are normalized to zero.



The values associated with these transitions are illustrated with the Bellman equations below:

Bellman Equations for Workers:

$$\rho J_u = \alpha(J_e^0 - J_u) \quad (5)$$

$$\rho J_e^0 = w - \lambda P + \lambda(J_e^1 - J_e^0) \quad (6)$$

$$\rho J_e^1 = w + z + \omega(J_r - J_e^1) \quad (7)$$

$$\rho J_r = z + \sigma(P - J_r) \quad (8)$$

Bellman Equations for Firms:

$$\rho \Pi_v = \beta(\Pi_f^0 - \Pi_v) \quad (9)$$

$$\rho \Pi_f^0 = (y - w) + \lambda(\Pi_f^1 - \Pi_f^0) \quad (10)$$

$$\rho \Pi_f^1 = (y - w) + \omega(\Pi_v - \Pi_f^1) \quad (11)$$

As an example, I describe the Bellman equation for an employed worker without a home (J_e^0), equation (6). While the individual is employed and does not have a home, he earns income from employment and searches for a home to purchase. With flow probability λ , the individual finds a home to purchase and incurs the price of the home, P . Upon purchase, the individual experiences the capital gains from becoming a home-owner. Thus, in equation (7), the individual derives utility from wage income and the value of homeownership, z . This continues until the individual experiences a health shock, retires, sells the home, and exits the economy.⁸ The Bellman equations for firms follow analogously.

4 Steady-State I (Exogenous Price of Housing)

I first take a look at a one-sided partial equilibrium model of the labor market. That is, I analyze labor market activity taking the price of housing as exogenous. The tractability of the model allows us to analytically determine how frictions in both the labor market and housing market affect labor market outcomes. Interestingly, the model highlights new mechanisms in which housing market conditions feed into labor market activity.

4.1 Bargaining

Once a match is created between a worker and firm, Nash bargaining is used to determine the wage paid to the worker. The wage agreement does not change throughout the duration of the match. Furthermore, workers and firms both generate surplus from the match. From the perspective of the worker, his surplus is the gain in utility from becoming employed. A firm's surplus is the gain in present discounted income from filling the vacancy. The gain in utility from becoming employed is $J_e^0 - J_u$. A worker will accept any wage such that $J_e^0 \geq J_u$. A firm's gain in income from filling a vacancy is $\Pi_f^0 - \Pi_v$. Similarly, a firm will agree to pay any wage such that the $\Pi_f^0 \geq \Pi_v$. Under symmetric Nash bargaining, the match surplus is split evenly between both agents:

⁸For tractability, retirement from the labor force and withdrawal from homeownership occur simultaneously. Alternatively, a health or 'retirement' shock and a shock to the utility from homeownership could be separate events. However, this would result in an additional worker state and Bellman equation in the model. Given that search takes place across two different markets (the labor market and the housing market) and wages and housing prices are endogenously determined, we pursue the strategy here in order to maintain analytical tractability.

$$J_e^0 - J_u = \Pi_f^0 - \Pi_v \quad (12)$$

It is important to consider the value of a job and how it relates to the wage offer function. The value of a job has two elements: labor income and the benefit associated with having access to housing. Going forward, consider the following definitions: $\hat{\beta} = \frac{\beta}{\rho+\beta}$, $\hat{\alpha} = \frac{\alpha}{\rho+\alpha}$, $\hat{\lambda} = \frac{\lambda}{\rho+\lambda}$, $\hat{\omega} = \frac{\omega}{\rho+\omega}$, and $\hat{\sigma} = \frac{\sigma}{\rho+\sigma}$. The gains from finding a job vacancy are:

$$J_e^0 - J_u = (1 - \hat{\alpha}) \left\{ \left[\frac{1}{(\rho + \lambda)} + \frac{\hat{\lambda}}{(\rho + \omega)} \right] w + \hat{\lambda} \left[\frac{1}{(\rho + \omega)} + \frac{\hat{\omega}}{(\rho + \sigma)} \right] z - \hat{\lambda} [1 - \hat{\omega} \hat{\sigma}] P \right\} \quad (13)$$

The value of a job reveals that housing market conditions have an important external effect on labor market activity. Notably, higher housing prices lower employment incentives because higher prices make it more difficult to attain the American Dream and enjoy the benefits of home-ownership.

Proposition 1 below demonstrates how overall market conditions affect wages:

Proposition 1 (The Wage Function). Under symmetric Nash bargaining, the wage function is:

$$w = \frac{(1 - \hat{\beta})}{(1 - \hat{\alpha})(1 - \hat{\lambda}\hat{\omega}\hat{\beta}) + (1 - \hat{\beta})} y \quad (14)$$

$$+ \left(\frac{\hat{\lambda}(\rho + \lambda)}{[(\rho + \omega) + \hat{\lambda}(\rho + \lambda)]} \right) \left(\frac{(1 - \hat{\alpha})(1 - \hat{\lambda}\hat{\omega}\hat{\beta})}{[(1 - \hat{\alpha})(1 - \hat{\lambda}\hat{\omega}\hat{\beta}) + (1 - \hat{\beta})]} \right) (\rho + \omega)(1 - \hat{\omega}\hat{\sigma})P$$

$$- \left(\frac{\hat{\lambda}(\rho + \lambda)}{[(\rho + \omega) + \hat{\lambda}(\rho + \lambda)]} \right) \left(\frac{(1 - \hat{\alpha})(1 - \hat{\lambda}\hat{\omega}\hat{\beta})}{[(1 - \hat{\alpha})(1 - \hat{\lambda}\hat{\omega}\hat{\beta}) + (1 - \hat{\beta})]} \right) \left(\frac{(\rho + \sigma) + \hat{\omega}(\rho + \omega)}{(\rho + \sigma)} \right) z$$

The wage equation illustrates that there are multiple components of the wage function. The wage function responds to labor productivity, utility from homeownership, and home prices. Furthermore, each component has a slightly different effect on the wage function. The following three Lemmas describe the three components of the wage function.

Lemma 1 (*Labor Productivity Effect on Wages*). The labor productivity effect on the wage function is given by the following term:

$$\frac{(1 - \hat{\beta})}{(1 - \hat{\alpha})(1 - \hat{\lambda}\hat{\omega}\hat{\beta}) + (1 - \hat{\beta})}y \quad (15)$$

The labor productivity effect is stronger if frictions facing home buyers are lower (λ higher). The labor productivity effect is independent of frictions facing sellers of homes.

The labor productivity component of the wage function is the standard component of wages in search and matching models of the labor market. As is typically the case, workers earn higher wages if they contact vacancies more easily. Similarly, they earn lower wages if it takes less time for vacancies to find unemployed workers in the labor market.

The contribution of my work comes from incorporating housing market activity into a model of the labor market. Notably, the model includes the motivation to search and buy a home. Consequently, in contrast to standard search models of the labor market, search frictions in the housing sector can also spill over to affect labor market activity. Interestingly, the labor productivity effect on wages is stronger when the frictions facing home buyers are lower.

Increasing the contact rate for home buyers reduces the average length of time it takes for an individual to buy a home. As a result, the amount of time from unemployment to home ownership is lower. This weakens the need for a worker to find employment in order to eventually become a homeowner. In turn, labor productivity has a stronger impact on wages. *That is, the worker will be able to extract a larger amount of revenue from their employer when it is easier to find a home.* Alternatively, wages will respond more to firm income when housing conditions are not as ‘tight.’ Therefore, my framework illustrates that policies directed towards the labor market cannot ignore the impact of conditions in the housing market.

For a given housing price, the labor productivity effect in the labor market is independent of the frictions facing sellers in the housing market. That is, the importance of labor productivity for wages does not depend on the ability of individuals to eventually sell their homes.

In order to put my results into perspective, it may help to consider the implications of recent activity within the context of my model. Estimates for 2012 put the growth rate of real GDP around a sluggish 2%. However, housing market conditions have improved. Consequently, the slight increase in tightness in the housing market implies that wages may not respond as much to the increase in GDP. That is, tighter frictions in the housing market would be associated with limited growth in wages. Alternatively, during

the housing boom which preceded the Great Recession, the model implies that wages would become less responsive to macroeconomic conditions. *Instead, as I explain below, labor market conditions would be likely to depend much more on activity in the housing market.*

As is clear from (13), higher housing prices are a work disincentive. Consequently, firms must compensate workers for the loss of surplus in order to fill their job vacancies. In this manner, my work is clearly distinct from previous research emphasizing the implications of individuals' housing equity on labor market incentives. Additional insights are summarized in the following Lemma:

Lemma 2 (*Home Price Effect on Wages*).

$$\left(\frac{\hat{\lambda}(\rho + \lambda)}{[(\rho + \omega) + \hat{\lambda}(\rho + \lambda)]} \right) \left(\frac{(1 - \hat{\alpha})(1 - \hat{\lambda}\hat{\omega}\hat{\beta})}{[(1 - \hat{\alpha})(1 - \hat{\lambda}\hat{\omega}\hat{\beta}) + (1 - \hat{\beta})]} \right) (\rho + \omega)(1 - \hat{\omega}\hat{\sigma})P \quad (16)$$

The home price effect of wage compensation depends on frictions in the labor market. It is decreasing in α and increasing in β . It also depends on frictions in the housing market – the effect is increasing in λ . However, it is unambiguously decreasing in σ .

Lemma 2 clearly demonstrates that there are important interactions between housing market and labor market conditions. To begin, a higher home price reduces the value of working because the surplus obtained from finding a job is lower if there are more severe costs for gaining access to housing. From this perspective, tighter housing market conditions (as exemplified by a higher home price) lead to higher work disincentives and higher wages.

While my result may appear counterintuitive, I believe it is bolstered by related evidence on housing prices and savings among renters. For example, Case, Quigley, and Shiller (2005) lament: “Thus it appears that housing prices may reduce, rather than increase the savings of renters.” Moreover, Engelhardt (1994) observes that higher housing prices are associated with a lower probability of savings among prospective home buyers in Canada. In particular, he finds that each additional \$1000 in housing prices contributes to \$300 less in assets among such households. That is, the available evidence indicates that incentives to save for a downpayment are lower if housing prices are higher. The novelty of my work is that I show that the same mechanisms also contribute to work disincentives in the labor market. *In other words, there are substantial financial disincentives and labor market disincentives from higher housing prices.*

Moreover, the Lemma shows that the magnitude of the home price effect also depends on *frictions* in

both sectors of the economy. First, the magnitude depends on labor market frictions. One of the important motivating factors for workers in the labor market is eventual access to a home. Thus, frictions in the labor market interact with housing market conditions and affect wage bargaining.

Notably, the higher housing price is a work disincentive, lowering the value of a job since the net surplus to be obtained in the housing market will be lower. However, as it becomes easier for workers to find a job, the amount of time that an individual will remain in the home is higher relative to their life span. *Therefore, the home price effect on wages is smaller if it is easier for workers to find a match in the labor market because the amount of time it takes to get access to the housing market is shorter.* That is, the work disincentive from higher housing prices is lower if it is easier for workers to find jobs. It is standard that the effects of the worker contact rate (α) are the opposite of the vacancy contact rate (β). However, the mechanisms from the housing market to labor market activity are new to the literature.

Second, the magnitude of the home price effect depends on frictions in the housing market. Moreover, as it is easier for workers to find a home, the discounted price of the home will increase. As a result, the compensation to the worker must increase. That is, the work disincentive from higher housing prices is higher if it is easier for a worker to match with a home in the housing market.

There is much attention in the housing literature on the utility that individuals obtain from homeownership. Yet, such factors do not appear in models of labor market activity. In particular, the value of home ownership is an important motivating factor for workers in the labor market as observed in the following lemma:

Lemma 3 (*Homeownership Effect on Wages*). *The importance of homeownership on the wage function is represented by:*

$$- \left(\frac{\hat{\lambda}(\rho + \lambda)}{[(\rho + \omega) + \hat{\lambda}(\rho + \lambda)]} \right) \left(\frac{(1 - \hat{\alpha})(1 - \hat{\lambda}\hat{\omega}\hat{\beta})}{[(1 - \hat{\alpha})(1 - \hat{\lambda}\hat{\omega}\hat{\beta}) + (1 - \hat{\beta})]} \right) \left(\frac{(\rho + \sigma) + \hat{\omega}(\rho + \omega)}{(\rho + \sigma)} \right)^z \quad (17)$$

The home ownership effect is increasing in α and decreasing in β . It is also decreasing in λ if ω is sufficiently small.

The interpretation of the homeownership effect is pretty close to the interpretation for the home price effect. The surplus from finding a job is higher when the utility from homeownership rises. As a result,

higher values of homeownership are associated with lower wages. However, frictions in each market affect the magnitude of the effect. *First, the negative impact of the ownership effect is stronger if α is higher.* The reasoning is the same as the home price effect – when it is easier for individuals to find a job, they get access to the surplus from housing in a shorter amount of time. That is, it becomes easier to get access to the utility from homeownership. *Consequently, the surplus from matching with an individual job vacancy is higher which accelerates the wage compression from housing.* The results for the remaining frictions follow analogously.

I conclude with a summary of three important conclusions from my partial equilibrium model of labor market activity:

1. Overall productivity and real GDP will have less impact on wage income if the housing market is tighter. (Labor Productivity Effect and Housing Frictions)
2. Housing prices should have a smaller impact on wages if it is easier for workers to find jobs. (Home Price Effect and Labor Frictions)
3. The utility from home ownership will have a larger impact on wages if it is easier for workers to find jobs. (Home Ownership Effect and Labor Frictions)

That is, search frictions in the housing market affect the magnitude of labor productivity on wages. Similarly, search frictions in the labor market affect the magnitude of housing prices on wage compensation.

4.2 Steady-State Equilibrium with Exogenous Price of Housing

I next formally define a steady-state equilibrium in the economy with an exogenous price of housing. I also establish that the steady-state exists and is unique.

Definition 1. A steady-state equilibrium in the economy with an exogenous price of housing, P , is a wage function $w(P, \beta, \alpha^*)$ and a vector (α^*, U^*) satisfying the following conditions:

- (i) (Symmetric Nash Bargaining):

$$J_e^{0*} - J_u^* = \Pi_f^{0*} - \Pi_v^* > 0 \tag{18}$$

(ii) (Steady State):

$$\alpha^*U^* = \beta^*V^* = m_0M(U^*, V^*) \quad (19)$$

$$\alpha^*U^* = \eta^* \quad (20)$$

The Steady-State Matching Condition

As the matching technology is constant returns to scale, the contact rate for an unemployed worker to a vacancy may be expressed as:

$$\alpha = m_oM\left(1, \frac{V}{U}\right). \quad (21)$$

Since $\alpha U = \beta V$, I can establish:

$$\alpha = m_oM\left(1, \frac{\alpha^*}{\beta}\right) = \alpha^{ss}(\beta; m_o). \quad (22)$$

This equation characterizes the steady state locus in the labor market. By Assumption 1, α^{ss} is also continuous. Its properties are summarized in the following Lemma:

Lemma 4. (*The Steady-State Locus in the Labor Market with an Exogenous Housing Price*) Under Assumption 1 the function $\alpha = \alpha^{SS}(\beta; m_0)$ satisfies the following properties:

$$(i) \partial\alpha^{SS}/\partial\beta < 0 \text{ and } \partial\alpha^{SS}/\partial m_0 > 0 \quad (ii) \lim_{\beta \rightarrow 0} \partial\alpha^{SS}/\partial\beta = -\infty \text{ and } \lim_{\beta \rightarrow \infty} \partial\alpha^{SS}/\partial\beta = 0$$

Exogenous Contact Rate of Vacancies

For simplicity, in the partial equilibrium model with exogenous housing prices, I assume there is a fixed number of firms operating in the economy. Consequently, the rate at which a vacancy contacts an unemployed worker is exogenous and independent of α . By comparison, in the general equilibrium framework, I consider endogenous entry of vacancies so that all matching rates are determined in steady-state equilibrium.

Characterization of Steady-State Equilibrium

As observed in the Figure below, it is easy to show that a unique steady-state in the economy with an exogenous housing price exists:

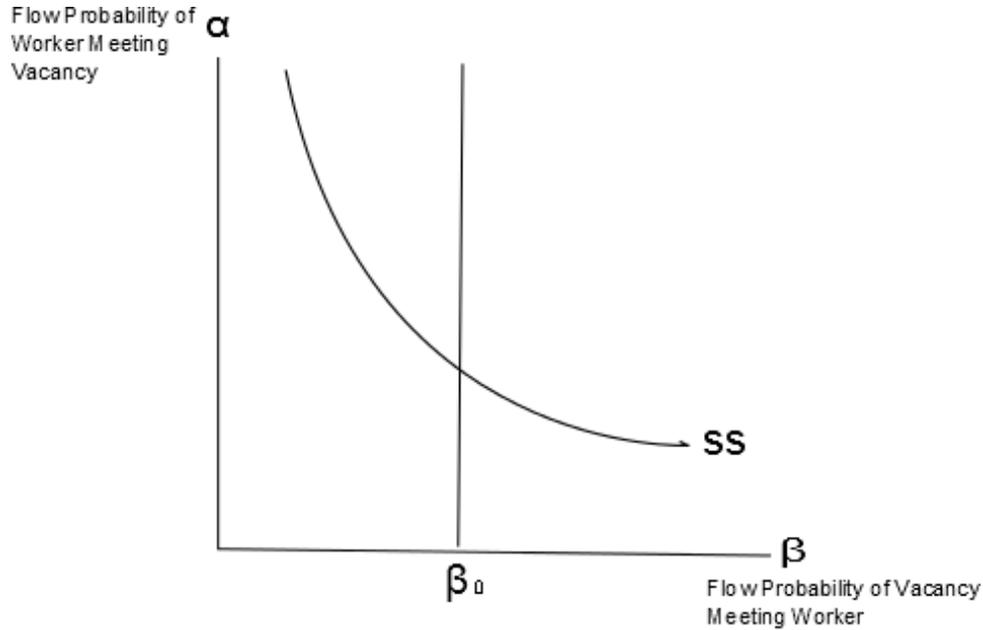


Figure 1: Existence and Uniqueness of Steady-State with Exogenous Price of Housing

Due to the downward-sloping property of the steady-state locus, an increase in β leads to a decrease in the steady-state equilibrium matching rate, α^* . An increase in m_0 will be associated with an increase in α^* since the steady-state locus will shift up.

5 Steady-State II (Exogenous Wage Rate)

I now turn to a partial equilibrium model of the housing market in which I assume wages are exogenous. In doing so, I address the question, “How does labor market activity affect housing market conditions?” I also study how the utility from homeownership feeds into housing prices.

Housing inventory depends on population demographics as reflected by ω . That is, individuals will sell their homes upon experiencing an aging shock in which they start to lose utility from owning a home. Demand for homes depends on the number of workers who exit unemployment and become attached to their jobs.⁹

⁹For example, Mankiw and Weil (1989) find that in the 1970s, housing prices experienced upward pressure as the baby boom generation entered the housing market.

The steady-state equilibrium consists of a housing price function, the steady-state population of buyers and sellers, and equilibrium contact rates between buyers and sellers. In particular, two conditions must be satisfied in the steady-state: (i) symmetric Nash bargaining over the price of a home and (ii) steady-state matching.

5.1 Bargaining

Following contact between a buyer and seller, Nash bargaining between the two determines the price of a home. Since individuals must be employed in order to gain access to the housing market, the match surplus for an individual acquiring a home is: $J_e^1 - J_e^0 - P$. A home buyer will agree to any price such that the value of being employed is greater or equal to the price he pays for his home, $J_e^1 - J_e^0 \geq P$. Similarly, the seller's value from selling their home is represented by $P - J_r$, the price they receive minus the value of being retired.

The positive surplus resulting from bargaining over the price of a home is divided evenly between the buyer and seller as dictated by the symmetric Nash rule:

$$P - J_r = J_e^1 - J_e^0 - P \quad (23)$$

In turn, the housing price function is presented in Proposition 2:

Proposition 2 (House Price). As determined by symmetric Nash bargaining, the house price function is:

$$P = \left(\frac{(\rho + \sigma)}{\rho + (\rho + \sigma)(1 - \hat{\omega}\hat{\sigma})(1 - \hat{\lambda})} \right) \left[\left(\frac{(1 - \hat{\lambda})}{(\rho + \omega)} - \frac{1}{(\rho + \lambda)} \right) w + \left(\frac{(1 - \hat{\lambda})}{(\rho + \omega)} + \frac{(1 - \hat{\lambda})\hat{\omega} + 1}{(\rho + \sigma)} \right) z \right] \quad (24)$$

There are two separate components of the house price function. Similar to the wage function, I split the home price function into two components. The following two lemmas describe the comparative statics of each component:

Lemma 5 (Labor Income Effect on Housing Prices). *The impact of wages on housing prices is represented by the following component of the house price function:*

$$\left(\frac{(\rho + \sigma)}{\rho + (\rho + \sigma)(1 - \hat{\omega}\hat{\sigma})(1 - \hat{\lambda})} \right) \left(\frac{(1 - \hat{\lambda})}{(\rho + \omega)} - \frac{1}{(\rho + \lambda)} \right) w \quad (25)$$

The labor income effect on housing prices depends on frictions in the housing market, but is independent of frictions in the labor market. It is decreasing in λ is sufficiently large. It is also decreasing in σ if ω is sufficiently low.

Since homeowners do not experience involuntary job separations, frictions in the labor market do not affect housing prices. So, what is the impact of labor market conditions on housing market activity? It primarily depends on earnings in the labor market.

Moreover, the impact of earnings on housing prices depends on the extent of search frictions in the housing market. Notably, labor market activity has less impact on housing prices if frictions facing home buyers are lower. The interpretation is pretty straightforward. As it becomes easier for buyers to find a suitable home, they have more options in the housing market. Consequently, the value of any particular match in the housing market is lower and housing prices depend more on the desire of individuals to sell their homes rather than the income of the buyer. *Alternatively, labor market activity has a stronger impact on housing market activity if the housing market is tight - if it is more difficult for buyers to find homes.*

Lemma 6 (Homeownership Effect on Housing Prices). *The value of homeownership on housing prices is represented by:*

$$\left(\frac{(\rho + \sigma)}{\rho + (\rho + \sigma)(1 - \hat{\omega}\hat{\sigma})(1 - \hat{\lambda})} \right) \left(\frac{(1 - \hat{\lambda})}{(\rho + \omega)} + \frac{(1 - \hat{\lambda})\hat{\omega} + 1}{(\rho + \sigma)} \right) z \quad (26)$$

The homeownership effect on housing prices is decreasing in λ . The effect of σ is ambiguous.

The impact of frictions facing buyers is intuitive. As it becomes easier for buyers to find a suitable home, the value of any particular home would be lower. Consequently, the importance of homeownership will be weaker if λ is higher.

5.2 Steady-State Equilibrium with an Exogenous Wage Rate

At this juncture, I formally define a steady-state equilibrium in the economy with an exogenous wage rate. I also demonstrate that the steady-state exists and is unique.

Definition 2. A steady-state equilibrium in the economy with an exogenous wage rate, w , is a price function $P(w, \sigma, \lambda^*)$ and a vector (λ^*, E_0^*) satisfying the following conditions:

(i) (Symmetric Nash Bargaining):

$$P^* - J_r^* = J_e^{1*} - J_e^{0*} - P^* > 0 \quad (27)$$

(ii) (Steady State):

$$\lambda^* E_0^* = \sigma R^* = h_0 H(E_0^*, R^*) \quad (28)$$

The Steady-State Matching Condition

As the matching technology is constant returns to scale, the contact rate for a home buyer may also be written as:

$$\lambda = h_o H\left(1, \frac{R}{E_0}\right) \quad (29)$$

Even further:

$$\lambda = h_o H\left(1, \frac{\lambda}{\sigma}\right) = \lambda^{ss}(\sigma, h_o) \quad (30)$$

This equation characterizes the steady-state locus in the housing market. By Assumption 2, λ^{ss} is continuous. Its properties are summarized in the following Lemma:

Lemma 7. (*The Steady-State Locus in the Housing Market with an Exogenous Wage Rate*) Under Assumption 2 the function $\lambda = \lambda^{SS}(\sigma, h_o)$ satisfies the following properties:

$$(i) \partial \lambda^{SS} / \partial \sigma < 0 \text{ and } \partial \lambda^{SS} / \partial m_0 > 0 \quad (ii) \lim_{\sigma \rightarrow 0} \partial \lambda^{SS} / \partial \sigma = -\infty \text{ and } \lim_{\sigma \rightarrow \infty} \partial \lambda^{SS} / \partial \sigma = 0$$

Exogenous Contact Rate of Sellers

For simplicity, in the partial equilibrium model with an exogenous wage rate, the rate at which a seller contacts a buyer is exogenous and independent of λ . By comparison, in the general equilibrium framework, all matching frictions will be endogenously determined.

Characterization of Steady-State Equilibrium

As observed in the Figure below, it is easy to show that a unique steady-state in the economy with an exogenous wage rate exists:

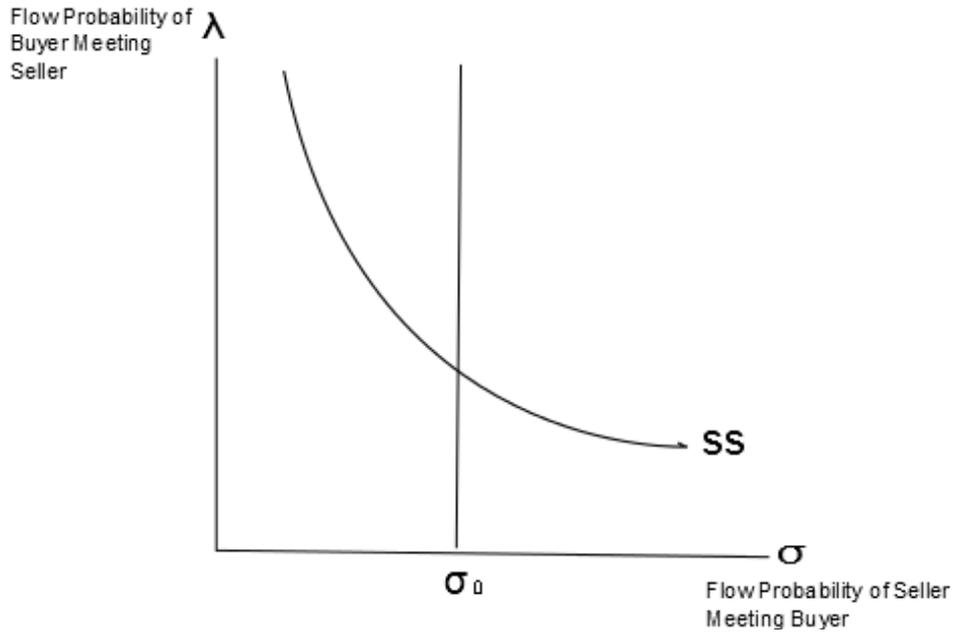


Figure 2: Existence and Uniqueness of Steady-State with Exogenous Wage Rate

Due to the downward-sloping property of the steady-state locus, an increase in σ leads to a decrease in the steady-state equilibrium matching rate, λ^* . An increase in h_0 will be associated with an increase in λ^* since the steady-state locus will shift up.

6 Steady-State III (General Equilibrium)

Finally, I turn to a general equilibrium framework in which housing prices and wages are both determined endogenously. As the general equilibrium model cannot be solved analytically, I choose to move towards a quantitative analysis in which wages and prices along with the level of transactions costs are all simultaneously determined.¹⁰ Doing so allows us to look at the magnitude of the deep connections between housing and labor market activity.

In order to understand the general equilibrium implications of my dual search structure, it is helpful to review the main insights from the two partial equilibrium models.

First, from the partial equilibrium model of the labor market:

1. Overall productivity and real GDP will have less impact on wage income if the housing market is tighter. (Labor Productivity Effect and Housing Frictions)

2. Housing prices should have a smaller impact on wages if it is easier for workers to find jobs. (Home Price Effect and Labor Frictions)

3. The utility from home ownership will have a larger impact on wages if it is easier for workers to find jobs. (Home Ownership Effect and Labor Frictions)

Second, from the model of the housing market:

4. Wages have a stronger impact on housing market activity if the housing market is tight (i.e., more difficult for buyers to find homes). (Labor Income Effect and Housing Frictions)

5. The utility from homeownership has a smaller impact on prices if the frictions facing buyers are lower. (Homeownership Effect and Housing Frictions)

¹⁰Given these significant connections, one might easily conclude that there are strategic complementarities between housing and labor market activity. Consequently, it is likely that multiple, Pareto-ranked levels of activity would emerge in a general equilibrium model of housing and labor market behavior. However, in our framework, wages and housing prices are strategic substitutes. For more discussion on strategic complementarities, see Cooper and John (1988).

6.1 Calibration

As I am moving on to numerical solutions for the model, the general equilibrium framework can be more flexible. To begin, in contrast to the partial equilibrium model of the labor market, I consider an economy with endogenous firm entry. That is, the steady-state number of job vacancies will be such that expected profits from creating a vacancy are exhausted: $\Pi_v^* = v_0$. In addition, following Shimer (2005), I set worker bargaining power to be equal to .72.

As I describe below, the model is parameterized so that it is able to match a number of important features of the U.S. economy. My principal focus is to study the implications of the model for two critical aspects of economic performance: housing and unemployment. Consequently, I am primarily interested in studying the implications of the model for housing prices and the duration of unemployment spells.

The calibration exercise aims at explaining behavior at the monthly frequency. Thus, I choose parameter values from the monthly frequency if possible. I set the monthly discount rate at $\rho = .0033$ from Head and Lloyd-Ellis. The rate at which firms contact workers, $\beta = 1.355$, corresponds to Shimer. The average duration of a vacant home in 2011, $\sigma = 0.12$, comes from the U.S. Census. Elasticities of the matching functions in the labor market and housing market, $\theta = 0.6$ and $\phi = 0.4$, are established in Blanchard and Diamond (1991) and Genesove and Han (2012). Using monthly GDP per capita and the average number individuals in a household, $y = 10,496$ in order to match median household income for 2011. Based upon available data, it takes about one month for the average homebuyer to find a suitable home to purchase. Therefore, the matching rate of homebuyers is equal to 1.

Since the duration of unemployment and housing prices are my two primary targeted variables to study, I have the following free parameters: z and v_0 .

Table 1: Parameter Values

Parameter symbol	Parameter value	Parameter and source
α	0.10	Matching rate for unemployed individuals (BLS)
β	1.355	Matching rate for vacancies (Shimer 2005)
η	0.009	Population growth rate
ρ	0.0033	Monthly discount rate (Head and Lloyd-Ellis)
σ	0.12	Matching rate of seller (US Census)
λ	1	Matching rate of buyer (US Census)
ω	0.028	Labor market withdrawal rate
θ	0.60	Elasticity of matching function in the Labor Market
ϕ	0.40	Elasticity of matching function in the Housing Market
χ	0.28	Bargaining power of the firm (Shimer 2005)
y	10,496	Output (World Bank)
z	1,317.25	Utility from owning a home
v_0	160,655	Cost of Creating Vacancy

After parameterizing the model I solve the system of eleven equations to pin down all of the endogenous variables in my model. Endogenous variables in the model are: the price of a home (P), the probability that a worker contacts a job vacancy (α), wages (w), the unemployment rate, the number of unemployed individuals (U), the number of employed individuals without a home (E_0), the number of employed individuals with a home (E_1), and the number of retirees (R) who are seeking to sell their homes. The matching parameters m_0 and h_0 are also free parameters which are determined in equilibrium.

Ideally, withdrawal of workers from the economy would be chosen based upon life-expectancy or the expected duration of active labor market participation. However, existence of a steady-state equilibrium is a problem if ω is too low. Instead, I pick $\omega = 0.028$ to correspond to the average length of time that a household remains in a home. Parameters z and v_0 are selected to match the average sales price of a new home in the United States in October 2011 and the average duration of unemployment. According to the U.S. Census Bureau, the median sales price of a new home in 2011 was equal to \$212,300. The average duration of unemployment at the time was 10 months, implying that α should be equal to 0.10. In order to match

these two outcomes, $z = 1317.25$. In addition, v_0 is pinned down at 160,655 reflecting the low job separation rate in the model. Moreover, wages must be sufficiently high to match housing prices. Consequently, the number of vacancies must be sufficiently low so that workers command sufficiently high wages. Please refer to Table 2 below for my baseline calculations:

Table 2: Baseline Calibration for Model

Duration of Unemployment Spell (α)	.10
Price of Home (P)	212,322
Wage (w)	4,880.67
Unemployed	.090
Employed without Home (E_0)	.009
Employed with a Home (E_1)	.316
Retired (R)	.075
Unemployment Rate	18.3%
Housing Matching Parameter (h_0)	.43
Labor Matching Parameter (m_0)	.64

My baseline model is pretty successful in matching the price of a home and the average duration of an unemployment spell. The flow probability of finding a job vacancy is right in line with the duration of unemployment in October 2011. The price of a home is slightly higher than in the data (\$212,300). However, the unemployment rate is much higher than October 2011.

With the baseline calculations in mind, I now seek to answer my first question: “*How do frictions in the labor market affect labor market activity and housing market conditions?*” To quantitatively address the question, I look at numerical calculations of my general equilibrium framework. From the number reported in Shimer (2005), I consider that firms are able to contact workers more easily. This could be interpreted as a reduction in tightness of the labor market. The flow probability, $\beta = 1.355$, indicates that it takes nearly three weeks (0.74 months) for a firm to fill a job vacancy. My alternative calculations that $\beta \approx 1.40$ imply that it only takes 0.71 months. That is, my calculations below are roughly based upon firms filling a vacancy about one day earlier. Please refer to Table 3 below:

Table 3: Housing Prices and Unemployment Spells
(The Impact of Lower Search Frictions Facing Firms in the Labor Market)

	Baseline (2011)	$\beta = 1.40$	$\beta = 1.41$
Duration of Unemployment Spell (α)	0.10	0.10	0.092
Price of Home (P)	212,322	212,320	212,319
Wage (w)	4,880.67	4,880.61	4,880.59
Unemployed	.09	.045	.041
Employed without Home (E_0)	.009	.009	.009
Employed with a Home (E_1)	.316	.316	.316
Retired (R)	.075	.075	.075
Unemployment Rate	18.3%	10.0%	9.2%
Housing Matching Parameter (h_0)	.43	.43	.43
Labor Matching Parameter (m_0)	.64	.64	.64

As can be observed from the Table, the reduction in search frictions facing firms primarily shows up in terms of lower unemployment. As frictions decline, the number of unemployed and the unemployment rate also decline. There is only a small impact on wages and housing prices. As illustrated in Figure 1 in the partial equilibrium model of the labor market, the flow probability that a vacancy contacts a firm must fall if the probability that a vacancy contacts a worker is higher.

Based upon the results in Table 3, labor market frictions do not appear to have much impact on housing prices – at least when the model is parameterized based upon the utility of owning a home. However, this is also likely to reflect the manner in which the labor market affects housing conditions. Recall my framework is designed to be free of “wealth effects” from the housing market. (See Cunningham and Reed (2012a,b)) By comparison, it is the desire of individuals to become a homeowner, the pursuit of the “American Dream,” that affects worker incentives and labor market and housing market activity.

I turn to my second question, “*How do frictions in the housing market affect labor market activity and housing performance?*” Based upon calculations from the U.S. Census Bureau, the flow probability of a vacant home finding a buyer is such that $\sigma = .12$. As a basis of comparison, I consider alternative

probabilities $\sigma = .16$ and $\sigma = .20$. These numbers imply that the time required for a seller would fall from over 8 months to 6.25 months and 5 months respectively. For the insights generated by the model, please refer to Table 4:

Table 4: The Impact of Lower Search Frictions from the Housing Market

	$\sigma = .12$	$\sigma = .16$	$\sigma = .20$
Duration of Unemployment Spell (α)	0.10	0.065	0.03
Price of Home (P)	212,322	216,936	221,757
Wage (w)	4,880.67	5,013.03	5,151.35
Unemployed	.09	.138	.290
Employed without Home (E_0)	.009	.009	.009
Employed with a Home (E_1)	.316	.316	.316
Retired (R)	.075	0.065	0.03
Unemployment Rate	18.3%	26.6%	44%
Housing Matching Parameter (h_0)	.43	.48	.525
Labor Matching Parameter (m_0)	.64	.40	.30

Obviously, if the market turns more favorable to sellers, prices in the housing market increase. The model indicates cutting the time to sell a home to nearly half would be associated with a roughly 4.5% increase in housing prices. However, higher prices in the housing market would have a significant negative external effect on the labor market. As it becomes more difficult to achieve the American Dream and buy a home, higher prices are a significant work disincentive, driving wages up by over 5.5% (since workers have more bargaining power than firms). In turn, unemployment spells and the economy's unemployment rate would increase dramatically. Thus, the calibration results clearly indicate that tight housing markets forge a significant barrier to employment in the labor market.

I now ask, “*Can the surge in housing prices during the recent housing boom (prior to the bust) be explained by my model? And, what impact would it have on the labor market?*” My calibration analysis was able to rationalize housing prices in October 2011 based upon the utility value of owning a home, z . So, an interesting

question is how much would housing incentives need to improve in order to boost prices back to the pre-housing bust levels. Table 5 attempts to match the level of housing price appreciation experienced during the housing boom in the United States:

Table 4: The Impact of Lower Search Frictions from the Housing Market

	$z = 1317.25$	$z = 1350$	$z = 1375$
Duration of Unemployment Spell (α)	.10	.053	.018
Price of Home (P)	212,322	217,599	221,629
Wage (w)	4,880.67	5,002.04	5,094.68
Unemployed	.09	.170	.481
Employed without Home (E_0)	.009	.009	.009
Employed with a Home (E_1)	.316	.316	.316
Retired (R)	.075	.075	.075
Unemployment Rate	18.3%	29.7%	54.6%
Housing Matching Parameter (h_0)	.43	.370	.244
Labor Matching Parameter (m_0)	.64	.43	.43

Based upon observations from the table, it is simply not possible to explain the surge in housing prices experienced during the boom based upon my model. If the utility from homeownership were to improve, housing prices would increase but it would lead to quite a loss in employment. The increase in the utility from homeownership would drive housing prices and wages up by the same amount, severely impacting the duration of unemployment spells along with an increase in unemployment. Again, as higher housing prices are a significant work disincentive, the model demonstrates that a strong housing market may have strong negative implications for labor market activity.

7 Conclusion

In response to the recent housing boom and bust in the United States, there has been increased attention to studying the implications of housing market activity for the labor market. For example, Dohmen (2005)

constructs a model of housing and unemployment in which housing restricts labor market mobility. Based upon the same approach, Coulson and Fisher (2009) pay special attention to wage determination in a model with labor market frictions. Their empirical findings indicate that homeownership is associated with lower wages but also a lower incidence of unemployment. Rather than focusing on the implications of homeownership, Cunningham and Reed (2012a,b) study the implications of housing equity for labor market outcomes using the American Housing Survey. In particular, they observe that negative equity plays a significant role in workers' incentives and outcomes. Notably, workers in a negative equity position earn wages that are around 7% lower than other homeowners.

Nearly all of the work on housing and labor markets is partial equilibrium in nature, studying outcomes among individuals with different housing endowments. My goal is to study the process of housing acquisition along with labor market activity. As a consequence of this approach, I show that the desire of individuals to establish stable employment so that workers can eventually purchase a home plays a significant role in labor market incentives. That is, the pursuit of the "American Dream" is an important component of activity in the labor market. As a result, frictions in the housing market can affect labor market activity. In turn, labor market frictions also play a role in housing markets.

The desire to purchase a home can greatly impact labor market activity. However, "tight" housing markets with higher prices limit access to housing and can significantly deteriorate the level of employment. This argument is supported by numerous calibration exercises in my work. For example, if frictions facing sellers in the housing market are lower, prices in the housing market increase. While this is good for sellers, it bears a significant negative external impact on the labor market. Workers, facing higher prices, command even higher wages as a result. Higher wages lead to longer unemployment spells and less job market activity. Consequently, my work suggests that policymakers should be very careful in implementing policies targeted towards housing - housing market conditions are likely to generate significant external effects to other sectors of the economy, especially the labor market.

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Chapter 2: Housing and Monetary Policy

1 Introduction

The connection between housing market activity and monetary policy has received a large amount of attention in recent years. How does monetary policy affect activity in the housing market? What role does housing play in overall macroeconomic activity? Moreover, how does optimal monetary policy depend on conditions in the housing sector?

Conventional wisdom views housing as a significant component of personal wealth in most countries. According to the Survey of Consumer Finances, U.S. primary residences made up approximately 30% of total household wealth in 2010. In addition to the bequest motive for accumulating housing wealth, saving through homeownership provides individuals with a mechanism for modifying consumption behavior. That is, a wide array of evidence demonstrates that housing wealth promotes consumption. For example, Carroll (2004) finds that the long-run marginal propensity to consume out of housing wealth to be around 9 cents per dollar. Furthermore, investment in residential structures and housing services is an important component of GDP. Based upon data from the Bureau of Economic Analysis, these two activities contributed to roughly 15.5% of GDP in the United States in 2012.

As housing is such a large component of economic activity, it is clearly important to understand the monetary transmission mechanism to the housing sector. Both Summers (1981) and Piazzesi and Schneider (2012) conclude that housing investment becomes more attractive relative to corporate capital during inflationary periods. In addition, Fama and Schwert (1977) find that housing investment is an effective way of avoiding the effects of inflation on real returns. Therefore, the available evidence indicates that it is important to disaggregate investment activity between the residential and non-residential sectors of the economy in formulating models of the macroeconomy. Yet, standard monetary growth models instead focus on the overall capital stock.

The objective of this paper is to develop a framework to study the transmission of monetary policy to the housing sector in a rigorous general equilibrium framework. To address the importance of housing for wealth accumulation, I develop a model in which housing is traded across generations of individuals. Moreover, as the motivation for housing wealth plays a role in household savings, housing is a significant factor in

intertemporal consumption behavior. In addition, individuals face liquidity risk which interferes with the ability to accumulate housing wealth. In contrast to the existing literature, I disaggregate the components of the overall capital stock since activity in the housing sector is distinct from non-residential activity. Finally, incomplete information provides a transactions role for money so that monetary policy can be studied.

As my focus centers on a framework in which housing is a reproducible asset that is traded over time, I analyze a three-period overlapping generations (OLG) economy. In the first period, young individuals work and save. In the second period, middle-aged individuals who are not exposed to liquidity shocks purchase homes and consume. In the final period, old homeowners finance their consumption based upon proceeds from the sale of their homes.

The model economy consists of two production sectors: the residential sector and non-residential sector which resembles the production sector in the standard neoclassical growth model. Thus, there are two types of capital: physical (non-residential) capital and residential capital. As in Schreft and Smith (1997, 1998), there are two geographically separate locations. The information friction which generates a transactions role for money emerges due to limited communication between both locations. This friction is aggravated by ‘random relocation’ shocks in which individuals are randomly moved to the other location. However, due to limited communication, privately-issued liabilities do not circulate. Restrictions on asset portability across locations imply that money must be used to overcome these frictions. Similar restrictions on asset portability are common in models of monetary economies – see, for example, Kocherlakota (2003). Fundamentally, the outcome of the relocation shock is equivalent to the liquidity preference shock in Diamond and Dybvig (1983). As a result of the idiosyncratic risk from the relocation shock, financial intermediaries arise to provide risk-pooling services.

While previous empirical work has shown that inflation stimulates housing sector activity, my research develops a rich framework to show that there are important asymmetries resulting from monetary stimulus. As in a large volume of work on housing, I show that the durability of housing as an asset plays a huge role. Moreover, I study how optimal policy intervention depends on conditions in the housing sector. Interestingly, I find that optimal money growth is higher if productivity in the residential sector is low. In this manner, I argue that policy should be designed according to supply conditions in the housing sector. By comparison, inflation should be lower when conditions favor housing demand.

The remainder of the paper is as follows: Section 2 describes the environment of the benchmark economy

and the banks behavior. In Section 3 I modify the benchmark model to include government transfers. Section 4 examines an economy with government debt as an asset choice in addition to physical capital, residential capital, and cash. Section 5 discusses what optimal monetary policy looks like in this environment. The final section is the conclusion.

2 Environment in the Benchmark Economy

I consider an economy with two separate locations. On each location, there is an infinite sequence of three-period lived overlapping generations. At the beginning of each period, a continuum of workers are born at each location with population mass equal to 1. Individuals born at date t are considered to be ‘*young*’, at date $t+1$ they are ‘*middle-aged*’ and at date $t+2$ they become ‘*old*.’ In the initial period both locations are populated with a young generation, middle-aged generation, and an initial old generation. Young agents are endowed with one unit of labor which they supply inelastically without any disutility from effort.

Production takes place in both locations. In each period, there are two separate sectors where production occurs: the residential sector and the non-residential sector. Homes are produced in the residential sector and physical (non-residential) capital is produced in the non-residential sector. As in the standard neoclassical growth model, physical capital is homogeneous with consumption. Production in the non-residential sector requires labor and physical capital as inputs. The production of housing only requires residential capital. The two different types of capital are not substitutable.

Young individuals work, but do not consume. Instead, individuals only desire to consume during middle and old-age. Based upon their accumulated savings, some individuals purchase homes in middle-age. Old individuals sell their homes to finance their consumption.

Using physical capital and the labor of young agents, a firm produces the consumption good using the production technology $Y_t = AK_t^\alpha L_t^{1-\alpha}$ where L_t represents labor, K_t denotes the level of the non-residential capital stock, and A represents a technology parameter in the non-residential sector. The capital-labor ratio in the non-residential sector is $k_t = \frac{K_t}{L_t}$.

Home builders produce homes using a single input, residential capital. The production function in the housing sector is $H_t = BK_t^h$ where K_t^h refers to the residential capital stock. Production functions of this type with constant returns to scale in the housing sector are often used in the supply-side literature

on housing. For example, Albouy and Ehrlich (2012) look at a two-factor model of housing production in which land and materials are the two primary inputs. As I am studying an economy with two sectors of production, there are two different stocks of capital: physical capital and residential capital. Thus, I simplify the presentation by aggregating land and materials together as one primary input – the residential capital stock. The parameter B reflects the level of productivity in the residential sector. That is, B is an important supply-side factor in the housing sector which is likely to vary over time due to regulatory changes, geographic constraints, and other factors such as construction costs.¹¹

As emphasized in numerous papers in urban economics, housing is durable over time. For example, Glaeser and Gyourko (2005b) stress that “...old housing does not disappear quickly. Housing may be the quintessential durable good, since homes often are decades, if not a century, old.” To emphasize the relative differences in durability between physical capital and housing, homes have depreciation rate δ while physical capital depreciates completely.¹²

In my baseline economy, there are four types of assets: money, physical capital, residential capital, and the stock of housing which includes both the previously existing stock of housing and newly constructed housing. The money supply is denoted as M_t and P_t represents the price level at period t . Thus, $m_t \equiv \frac{M_t}{P_t}$ is the real per capita money supply and $\frac{P_t}{P_{t+1}}$ represents the gross real return on money balances. The monetary authority follows a standard money-growth rule in which σ represents the growth rate of the money stock:

$$M_{t+1} = (1 + \sigma)M_t. \tag{31}$$

At the end of their youth, individuals face the possibility of being relocated to the other location at the beginning of their middle-age. The probability of relocation is equal to π and is publicly known. Each middle-aged individual is subject to the same probability of relocation. There is limited communication across islands so privately-issued liabilities do not circulate. Moreover, money is the only asset that can cross locations. Neither residential capital or physical capital is portable. Consequently, individuals who experience relocation shocks liquidate all of their assets at the end of their youth. Thus, following Diamond-Dybvig (1983), the relocation shock is a form of liquidity risk. In this manner, I refer to the relocation shock

¹¹See Epple et al. (2010) for discussion on housing production functions. Glaeser et al. (2008) argue that limited housing supply is a key determinant in housing price appreciation that takes place in housing bubbles. Glaeser et al. (2005a,b) look at determinants of housing supply.

¹²Ghossoub and Reed (2013) demonstrate that multiple monetary steady-state equilibria are possible if capital is durable and traded over time in a one-sector neoclassical growth model.

as a liquidity shock throughout the paper. Individuals who are forced to relocate are called ‘movers’ while the other middle-aged are ‘non-movers.’

Perfectly competitive banks arise to provide risk pooling services to individuals as a result of the idiosyncratic risk that they may encounter. Banks accept deposits from the young and choose a portfolio of physical capital, residential investment, and money balances on their behalf. As movers exhaust all of their savings at the beginning of their middle-age, the expected lifetime utility of an agent is:

$$U(c_{t+1}^m, c_{t+1}^n, h_{t+1}, c_{t+2}) = \pi \ln(c_{t+1}^m) + (1 - \pi) [\phi \ln(h_{t+1}) + (1 - \phi) \ln(c_{t+1}^n) + \beta \ln(c_{t+2})] \quad (32)$$

The timing of the model is described as follows and is illustrated in Figure 1. In the beginning of the first period, firms hire workers, rent capital, and produce in each sector. Workers are paid their wage income which is deposited in the bank. Next, banks determine their portfolio allocation. Then, workers learn if they will have to relocate. Movers liquidate their assets.

In the beginning of the next period, non-movers will purchase a home with the accumulated savings. Movers transition to their new locations. Movers use their bank returns to consume the consumption good while non-movers’ level of consumption derives from their net income after financing housing expenditures. In the following period, non-movers liquidate their homes and use the proceeds to finance consumption.

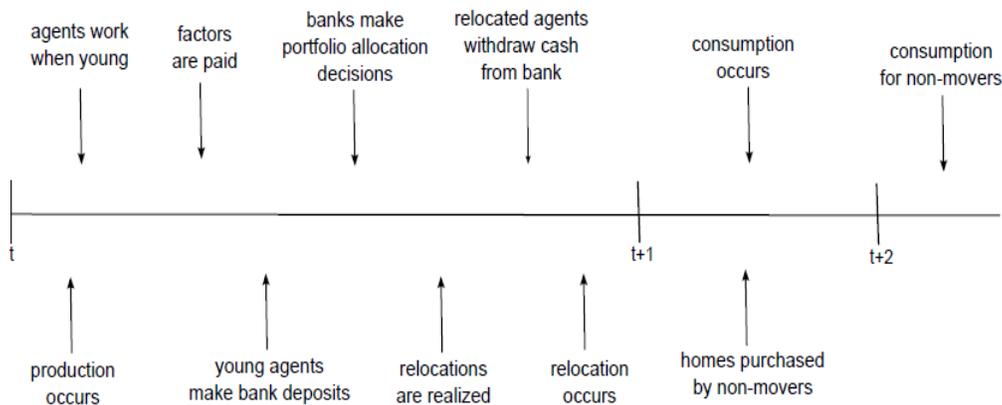


Figure 1: Timing of Events

2.1 Trade

2.1.1 Factor Markets

At the beginning of every period production takes place and input factors are paid. Factor markets are perfectly competitive so factors are paid their marginal products. Consumer good producers rent physical capital from banks and use the labor provided by young agents to produce. Wages are given by:

$$w_t = A(1 - \alpha)k_t^\alpha \quad (33)$$

The rental rate for physical capital is ρ_t :

$$\rho_t = A\alpha k_t^{\alpha-1} \quad (34)$$

Home builders use a single input, residential capital, which it rents from the bank at the rental rate r_t :

$$r_t = P_{h,t}B \quad (35)$$

2.1.2 Housing Demand

As previously stated, non-movers purchase homes based upon their accumulated savings in their middle-age. In contrast, individuals who experience relocation shocks consume all of their savings during middle age, leaving no resources to consume while old. A non-mover's accumulated wealth in their middle-age is equal to the return on their savings $r_t^n w_t$ in which r_t^n denotes the return a non-mover will earn from deposits in the amount w_t . Housing demand by non-movers solves the following problem:

$$\underset{h_{t+1}}{\text{Max}} \phi \ln(h_{t+1}) + (1 - \phi) \ln(c_{t+1}^n) + \beta \ln(c_{t+2}^n) \quad (36)$$

subject to:

$$c_{t+1}^n = r_t^n w_t - P_{h,t+1} h_{t+1} \quad (37)$$

$$c_{t+2}^n = (1 - \delta)P_{h,t+1}h_{t+1} \quad (38)$$

As housing is a form of wealth accumulation, it also represents a consumption-savings decision in middle-age. At this time, homeowners reap the utility gains from purchasing a residence. However, it leaves less income available for personal consumption expenditures. In old-age, non-movers use the proceeds from selling their home to finance consumption.

The solution to the individual's lifetime utility maximization problem generates the following demand for housing:

$$h_{t+1} = \left(\frac{(\phi + \beta)}{(1 + \beta)} \right) \left(\frac{r_t^n w_t}{P_{h,t+1}} \right) \quad (39)$$

As observed in (39), an individual's demand for housing depends on a number of factors. Of course, the amount of savings affects their home affordability. If individuals value homeownership more (as exhibited by higher values of ϕ), their demand for housing will also be greater. That is, ϕ represents the consumption value of homeownership. Moreover, housing is the principal form of savings among the middle-aged. At higher rates of time preference over old-age utility, the ability to save through housing is also an important driver of housing demand. Finally, an individual's housing demand function is decreasing in the price of the housing stock. In turn, the consumption of a middle-aged person will be:

$$c_{t+1}^n = \frac{(1 - \phi)}{(1 + \beta)} r_t^n w_t \quad (40)$$

In particular, consumption of middle-aged individuals will be lower if they derive more utility from homeownership and housing expenditures will be relatively high.

By comparison, consumption of old-age individuals will be financed by their housing wealth:

$$c_{t+2}^n = \left(\frac{(1 - \delta)(\phi + \beta)}{(1 + \beta)} \right) r_t^n w_t \quad (41)$$

As housing wealth depends on their accumulated savings from their youth, the consumption of old individuals will depend on the interest income earned as well as the utility from owning a home.

2.1.3 The banks' problem

Based upon the anticipated demand for housing of a non-mover, a bank chooses a portfolio assets to acquire on behalf of the middle-aged prior to the realization of the liquidity preference shock. Workers who are relocated must liquidate their deposit balances into money. This liquidity preference shock provides a role for financial intermediation by banks. Banks insure individuals against liquidity shocks by pooling their idiosyncratic risks and choosing a portfolio of assets on their behalf. After receiving wage deposits from every worker, the bank allocates deposits between three assets: fiat currency (m_t), physical capital (i_t), and residential capital (i_t^h). The allocation of assets is limited by a bank's deposit base. Hence, the bank's balance sheet is expressed as:

$$w_t \geq m_t + i_t + i_t^h \quad (42)$$

Banks promise returns to both movers and non-movers. The returns to movers and non-movers are denoted as r_t^m and r_t^n , respectively. Given that movers must acquire money before they relocate, the return to movers will depend on the amount of money that the bank acquires and the inflation rate:

$$\pi r_t^m w_t \leq m_t \left(\frac{P_t}{P_{t+1}} \right) \quad (43)$$

Comparatively, the return paid to non-movers depends upon the return on the bank's investment in physical capital and residential capital. The return to physical capital is ρ , and the return to residential capital is denoted as r . This creates an additional constraint for the bank:

$$(1 - \pi) r_t^n w_t \leq i_t \rho + i_t^h r \quad (44)$$

Since banks are perfectly competitive, the objective of each bank is to maximize the expected lifetime utility among its depositors. However, choosing a portfolio to obtain this objective requires understanding how much non-movers will want to consume in old-age along with their demand for housing.

Based upon the anticipated demand for housing, the bank chooses m_t , i_t , and i_t^h to solve:

$$\begin{aligned} \underset{m_t, i_t, i_t^h}{Max} \quad & \pi \ln(r_t^m w_t) + (1 - \pi) \left[\phi \ln \left(\frac{(\phi + \beta) r_t^n w_t}{(1 + \beta) P_{h,t+1}} \right) + (1 - \phi) \ln \left(\frac{(1 - \phi)}{(1 + \beta)} r_t^n w_t \right) \right] \\ & + (1 - \pi) \left[\beta \ln \left(\frac{(1 - \delta)(\phi + \beta)}{(1 + \beta)} r_t^n w_t \right) \right] \end{aligned} \quad (45)$$

$$\text{s.t. } r_t^m = \frac{m_t}{\pi w_t} \left(\frac{P_t}{P_{t+1}} \right) \quad (46)$$

$$r_t^n = \frac{i_t \rho + (w_t - m_t - i_t) r}{(1 - \pi) w_t} \quad (47)$$

$$w_t = m_t + i_t + i_t^h \quad (48)$$

In order for the bank to invest in both sectors of the economy, a no-arbitrage condition between capital in both sectors must be satisfied:

$$\rho_t = r \quad (49)$$

Money demand is given by:

$$m_t = \frac{\pi w_t}{(1 - \pi)\beta + 1} \quad (50)$$

In comparison to the standard two-period random relocation model using log-preferences, the probability of not being relocated factors into the banks' demand for money. Each bank's problem involves providing income to different groups of individuals after the realization of liquidity shocks. For example, non-movers value income which they use in their choice of housing. Their anticipated housing wealth in old-age finances their old-age consumption. Consequently, the rate of time preference towards old-age utility is a component of money demand by each bank.

2.2 General Equilibrium

I now define the equilibrium for my baseline economy. One of the goals of the model is to determine the amount of housing supply and the relative price of housing. The amount of residential capital in each period depends on previous investment in the residential sector of the economy:

$$i_t^h = k_{t+1}^h \quad (51)$$

A similar relationship occurs in the non-residential sector:

$$i_t = k_{t+1} \quad (52)$$

2.2.1 Residential Investment

Using the bank's balance sheet in conjunction with the (49), (33), (51), and (52), I obtain the derived investment demand for residential capital by a bank. The derived investment demand depends on prices and productivity in the residential sector because each intermediary factors anticipated housing demand among non-movers in choosing the portfolio of assets to acquire on behalf of its depositors:

$$K_{t+1}^h = A(1 - \alpha)(1 - \pi) \left(\frac{A\alpha}{P_{h,t+1}B} \right)^{\frac{\alpha}{1-\alpha}} \left(\frac{1 + \beta}{1 + (1 - \pi)\beta} \right) - \left(\frac{A\alpha}{P_{h,t+1}B} \right)^{\frac{1}{1-\alpha}} \quad (53)$$

Notably, residential investment is lower at higher prices of housing. At higher prices, individuals who have savings to acquire homes will have lower housing demand. The intermediary factors anticipated demand conditions in choosing the level of residential investment.

2.2.2 Housing Demand and Consumption

Based upon the portfolio choice of the bank, the rate of return to non-movers can be expressed in terms of the price of housing. After substitution into (39), the demand for housing by a middle-aged non-mover is:

$$h_{t+1}^* = \left(\frac{BA(1-\alpha)(\phi+\beta)(1-\pi)}{1+\beta(1-\pi)} \right) \left(\frac{A\alpha}{P_{h,t+1}B} \right)^{\frac{\alpha}{1-\alpha}} \quad (54)$$

First, housing demand will depend on net income available after money balances. Higher financial returns would then improve the demand for housing.

I turn the effects of productivity in the housing sector, B . While it would be natural to assume that productivity is a supply-side factor and only affects housing demand through the price of housing ($P_{h,t+1}$), housing productivity affects housing demand in my framework through factor markets and financial returns. Notably, the higher the return to residential capital in the housing sector (higher values of $P_{h,t+1}B$), the less capital will be allocated to non-residential sector. As a result of lower amounts of investment in the non-residential sector, wages will be lower since labor and non-residential capital are complements in the production of non-residential goods. However, there is a competing factor due to the higher financial returns on savings for non-movers which promotes the demand for housing in (54). Higher levels of total factor productivity (productivity in the non-residential sector) have two effects on an individual's housing demand. First, productivity in the non-residential sector raises wages because it attracts more investment. Second, it leads to higher financial returns.

In addition, there will be more demand for homes (above their role in wealth accumulation) if individuals derive a higher level of utility from homeownership. Higher housing prices are associated with less demand for housing. Armed with financial returns and housing demand, I may now determine the levels of consumption among all individuals as a function of housing prices:

$$c_{t+1}^m = \left(\frac{A(1-\alpha)}{1+\beta(1-\pi)} \right) \left(\frac{A\alpha}{P_{h,t+1}B} \right)^{\frac{\alpha}{1-\alpha}} \quad (55)$$

$$c_{t+1}^n = \left(\frac{A\alpha}{P_{h,t+1}B} \right)^{\frac{\alpha}{1-\alpha}} \left[\frac{A\alpha(1-\alpha)(1+\beta)}{(1-\alpha)(1-\pi)[1+\beta-\delta(\phi+\beta)]} - \left(\frac{BA(1-\alpha)(\phi+\beta)(1-\pi)}{1+\beta(1-\pi)} \right) P_{h,t+1} \right] \quad (56)$$

$$c_{t+2}^n = (1-\delta)P_{h,t+1} \left(\frac{BA(1-\alpha)(\phi+\beta)(1-\pi)}{1+\beta(1-\pi)} \right) \left(\frac{A\alpha}{P_{h,t+1}B} \right)^{\frac{\alpha}{1-\alpha}} \quad (57)$$

2.2.3 Equilibrium in the Housing Market

The total demand for housing comes from aggregating the housing demand across all of the non-movers:

$$D_t^h = (1 - \pi)h_t \quad (58)$$

I next seek to determine the equilibrium relative price of housing. In each period, new housing supply depends upon residential investment: $H = BK^h$. On the other side of the housing market, demand for new housing depends on the amount that depreciates over time: δD^h .

The equilibrium price of housing is achieved when total supply and total demand for new housing is the same:

$$P_{h,t}^* = \frac{\alpha [1 + \beta(1 - \pi)]}{B [1 + \beta - \delta(\phi + \beta)] (1 - \pi)} \quad (59)$$

At higher levels of productivity in the residential sector, the equilibrium price of housing is lower due to the increase in housing supply. Steady-state housing prices also depend on conditions in the non-residential sector. Notably, the capital-share of production in the non-residential sector is associated with higher prices in the housing market. If production in the non-residential sector is more capital-intensive, the capital intensity pulls resources away from the housing market and causes prices to be higher. Prices are also higher if individuals place a higher valuation on utility in old-age which contributes to an increase in housing demand.

2.2.4 Steady-State Equilibrium Macroeconomic Activity

I choose to study macroeconomic activity in the steady-state. As I have shown, steady-state macroeconomic activity is highly dependent on conditions on the housing sector. Therefore, I am able to determine steady-state outcomes across all sectors in the economy with the solution for equilibrium housing prices (P_h^*) in (59). After imposing steady-state on the system of equilibrium conditions, I proceed by studying the steady-state levels of investment in each sector which are synonymous with the residential and non-residential capital stocks:

Proposition 1. Let $\delta < \frac{(\phi+\beta)}{(1+\beta)}$. Under this condition, a (non-degenerate) steady-state equilibrium exists. In the steady-state, the equilibrium levels of residential and non-residential capital are:

$$K^* = \left[\frac{A[1 + \beta - \delta(\phi + \beta)](1 - \alpha)(1 - \pi)}{1 + \beta(1 - \pi)} \right]^{\frac{1}{1-\alpha}} \quad (60)$$

$$K^{h*} = \left(\frac{A(1 - \alpha)(1 - \pi)(1 + \beta)}{1 + \beta(1 - \pi)} \right)^{\frac{1}{1-\alpha}} \left(\frac{1 + \beta - \delta(\phi + \beta)}{1 + \beta} \right)^{\frac{\alpha}{1-\alpha}} - K^* \quad (61)$$

As previously emphasized, it is important to disaggregate the components of the overall capital stock as the production function varies across sectors. Such differences contribute to substantially different levels of activity in the steady-state as witnessed by (60) and (61). Moreover, it is also clear that each sector competes for resources – the residential capital stock is the total amount of investment in each period net of investment in the non-residential sector. In addition, fundamentals in each sector have different effects on investment in the steady-state. Notably, higher levels of productivity in the non-residential sector stimulate investment in both sectors but productivity in the residential sector does not affect investment in either sector.

I seek to study how financial returns and consumption are determined in the steady-state. For tractability, I look at a special case of capital intensity in the non-residential sector where $\alpha = 1/2$:

Lemma 1. Suppose that $\alpha = 1/2$. In addition, let $\delta < \frac{(\phi+\beta)}{(1+\beta)}$. Under these conditions, the steady-state levels of residential and non-residential capital are:

$$K^* = \left(\frac{A^2}{4} \right) \left(\frac{[1 + \beta - \delta(\phi + \beta)](1 - \pi)}{[1 + \beta(1 - \pi)]} \right)^2 \quad (62)$$

$$K^{h*} = \left(\frac{\delta(\phi + \beta)}{[(1 + \beta) - \delta(\phi + \beta)]} \right) K^* \quad (63)$$

In this case, the connections between both sectors of the economy are quite apparent – the residential capital stock is directly proportional to the non-residential stock of capital. Total factor productivity (A) clearly drives investment in both sectors higher. In addition, there is more investment in both sectors of the economy if liquidity risk is not as severe (π lower).

It is also clear that housing fundamentals have asymmetric effects across sectors. Durability of housing leads to less residential investment and more non-residential investment. By comparison, higher valuations for housing services drive residential investment up and lower non-residential investment.

I continue by studying steady-state returns in the banking sector and consumption across segments of the population.

Returns to Deposits:

$$r^{m*} = \frac{1}{1 + \beta(1 - \pi)} \quad (64)$$

$$r^{n*} = \frac{\alpha(1 + \beta)}{(1 - \alpha)(1 - \pi)[1 + \beta - \delta(\phi + \beta)]} \quad (65)$$

Returns paid to movers are primarily independent of the return to capital in either sector of the economy. This property reflects the logarithmic form of preferences in which the substitution and income effects of higher returns to capital offset each other.

In contrast, returns paid to non-movers in the banking sector depend on conditions in both capital sectors. For example, returns are higher if the non-residential sector is more capital-intensive. Moreover, returns to non-movers in the banking sector are higher if fundamentals in the housing sector favor higher housing prices (due to higher rates of depreciation of housing, a greater consumption value of housing, and a greater desire to invest in housing as a form of wealth accumulation). Higher housing prices raise returns to investment in the residential sector of the economy and support the ability of banks to pay higher rates of return to deposits.

Steady-State Consumption:

$$c^{m*} = \left(\frac{(1 - \pi)}{1 + \beta(1 - \pi)} \right) \frac{A^2 [1 + \beta - \delta(\phi + \beta)]}{4 [1 + \beta(1 - \pi)]} \quad (66)$$

$$c_1^{n*} = \frac{A^2 [(1 + \beta) - (\phi + \beta)(1 - \pi)]}{4 [1 + \beta(1 - \pi)]} \quad (67)$$

$$c_2^{n*} = \frac{A^2(1-\pi)(1-\delta)(\phi+\beta)}{4[1+\beta(1-\pi)]} \quad (68)$$

As a result of the large amount of housing price appreciation before the housing bust, there has been much attention to studying the marginal propensity to consume out of housing wealth. Based upon aggregate data from U.S. states, Case, Quigley, and Shiller (2005) find a marginal propensity to consume equal to around 4 cents. Campbell and Cocco (2004) look at micro-level data for households in the UK and find that higher housing prices lead to increased consumption among homeowners, but not renters. In contrast, Carroll (2004) finds that the long-run marginal propensity to consume out of housing wealth to be around 9 cents per dollar.

Time-series approaches used to estimate the marginal propensity to consume are constructed in the following way. First, estimate a process for changes in housing wealth. Second, look at a series of changes in consumption. The marginal propensity to consume looks at the slope of the latter process over the former.

Interestingly, my framework can be used to draw insights into this phenomenon. In particular, I derive the MPC out of housing wealth when changes in housing wealth are driven by higher levels of productivity. The impact of productivity in the non-residential sector on housing prices is:

$$\frac{\partial(P_h^* * h^*)}{\partial A} = \frac{A(\phi+\beta)(1-\pi)}{2[1+\beta(1-\pi)]} \quad (69)$$

Notably, productivity has a larger impact on housing wealth if individuals derive higher levels of utility from homeownership and they value owning as a form of wealth accumulation because they have a higher rate of time preference.

I next turn to studying how productivity affects the consumption of non-movers who are also homeowners:

$$\frac{\partial c_1^{n*}}{\partial A} = \frac{A[(1+\beta) - (\phi+\beta)(1-\pi)]}{2[1+\beta(1-\pi)]} \quad (70)$$

$$\frac{\partial c_2^*}{\partial A} = \frac{A(1-\pi)(1-\delta)(\phi+\beta)}{2[1+\beta(1-\pi)]} \quad (71)$$

While the effect of productivity of a non-mover in middle-age is decreasing in the value of homeownership, the effect is increasing for the old who finance their consumption out of housing wealth.

Aggregating across both periods is equivalent to looking at the aggregate consumption across both groups of homeowners in the steady-state. As a result, the MPC out of housing wealth is:

$$MPC^* = \frac{1+\beta-\delta(\phi+\beta)(1-\pi)}{(\phi+\beta)(1-\pi)} \quad (72)$$

Interestingly, the MPC is exclusively dependent on fundamentals in the housing sector. Of course, the durability of housing is a significant factor. If housing is more durable, housing is a more productive form of wealth accumulation and individuals can spend more as housing wealth increases. It is decreasing in the utility from homeownership – as productivity drives up housing wealth, it is also associated with greater housing expenditures which detracts from the desire of individuals to spend on consumption. The rate of time preference is also a key component of the MPC.

In this environment money is super-neutral. However, available evidence indicates that inflation does have important effects on housing market activity. I turn to the relationship between inflation and housing market activity in the following section.

3 Non-Superneutral Effects of Monetary Policy

In the preceding section, all revenues from seigniorage were consumed by the government. Since the revenues from the inflation tax were not redistributed back to the economy, monetary policy was superneutral and did not have any effect on real economic activity. By stripping out real effects from monetary policy, the benchmark framework elucidates how the fundamentals of the housing market affect overall macroeconomic activity.

However, the superneutrality of money is clearly at odds with empirical evidence demonstrating that inflation has a significant impact on economic activity through the housing sector. For example, both

Summers (1981) and Piazzesi and Schneider (2012) find that housing investment becomes more attractive relative to corporate capital in inflationary episodes. Moreover, Ahmed and Rogers (2000) find evidence of a long-run Tobin effect for the United States. Thus, the available evidence points to two important observations to address. First, it is important that a model of investment activity produces a positive relationship between inflation and investment. Second, monetary policy produces asymmetric effects on investment – residential investment should show a stronger response to inflation than non-residential investment.

In the following two sections, I seek to address the non-superneutral effects of monetary policy in the housing market and the consequences for macroeconomic performance. Rather than promoting government consumption, in this section, all seigniorage revenues are redistributed to the economy in the form of lump-sum transfers to the young.¹³ In the next section, seigniorage revenues promote inflation-financed public credit obligations as in Schreft and Smith (1997, 1998).

Due to the revenues from money creation, the government’s budget constraint is:

$$\tau_t = \frac{\sigma}{1 + \sigma} m_t \quad (73)$$

Seigniorage revenues provide the government with income which it redistributes to young individuals in the lump-sum amount, τ_t . Consequently, young individuals have two sources of income. Income from the labor market equal to w_t and income from transfers, τ_t .

Due to the increase in income, a representative non-mover’s housing demand is:

$$h_{t+1} = \left(\frac{(\phi + \beta)}{(1 + \beta)} \right) \left(\frac{r_t^n (w_t + \tau_t)}{P_h} \right) \quad (74)$$

Consumption across time-periods directly follows the analysis in the benchmark model:

$$c_{t+1}^n = \frac{(1 - \phi)}{(1 + \beta)} r_t^n (w_t + \tau_t) \quad (75)$$

¹³The redistribution of seigniorage to the young is pretty standard in monetary models with liquidity risk. See, for example, Bhattacharya and Singh (2010).

$$c_{t+2}^n = \left(\frac{(1-\delta)(\phi+\beta)}{(1+\beta)} \right) r_t^n (w_t + \tau_t) \quad (76)$$

Obviously, housing demand and consumption are all affected by the transfers from the government.

The portfolio choices of the bank are virtually the same as the benchmark model. Again, a no-arbitrage condition implies that the returns to capital in either sector of the economy are the same:

$$P_{h,t}B = A\alpha K_t^{\alpha-1} \quad (77)$$

Money balances and the bank balance sheet are affected by the size of the transfers:

$$m_t = \frac{\pi(w_t + \tau_t)}{(1-\pi)\beta + 1} \quad (78)$$

$$(w_t + \tau_t) = m_t + i_t + i_t^h \quad (79)$$

3.1 Steady-State General Equilibrium

As previously stated, workers are paid their marginal product of labor in equilibrium. Combining (77), (79), (73), (78), and (33) I attain a steady-state relationship between residential capital and housing prices that determines the level of residential investment:

$$K^h = A(1-\alpha) \left(\frac{A\alpha}{P_h B} \right)^{\frac{\alpha}{1-\alpha}} \left(\frac{(1-\pi)(1+\beta)}{(1-\pi)\beta + 1 - \frac{\sigma}{1+\sigma}\pi} \right) - \left(\frac{A\alpha}{P_h B} \right)^{\frac{1}{1-\alpha}} \quad (80)$$

For a given price of housing, higher inflation raises seigniorage. With the additional level of deposit income received by the bank, residential investment is also higher.

As in the benchmark model, the portfolio choice of the bank provides information about the rate of return to non-movers so that an individual's housing demand can be expressed as a function of the price of housing:

$$h = \left(\frac{A(1-\alpha)B(\phi+\beta)}{(1-\pi)\beta + 1 - \frac{\sigma}{1+\sigma}\pi} \right) \left(\frac{A\alpha}{P_h B} \right)^{\frac{\alpha}{1-\alpha}} \quad (81)$$

In turn, consumption across the different segments of the population is:

$$c^m = \left(\frac{A(1-\alpha)}{(1-\pi)\beta + 1 - \frac{\sigma}{1+\sigma}\pi} \right) \left(\frac{A\alpha}{P_h B} \right)^{\frac{\alpha}{1-\alpha}} \quad (82)$$

$$c_1^n = \left(\frac{A(1-\alpha)P_h B(1-\phi)}{(1-\pi)\beta + 1 - \frac{\sigma}{1+\sigma}\pi} \right) \left(\frac{A\alpha}{P_h B} \right)^{\frac{\alpha}{1-\alpha}} \quad (83)$$

$$c_2^n = \left(\frac{(1-\delta)(\phi+\beta)A(1-\alpha)P_h B}{(1-\pi)\beta + 1 - \frac{\sigma}{1+\sigma}\pi} \right) \left(\frac{A\alpha}{P_h B} \right)^{\frac{\alpha}{1-\alpha}} \quad (84)$$

For a given price of housing, a higher money growth rate stimulates consumption across all segments of the population.

3.2 Equilibrium in the Housing Market

The amount of residential investment affects the total supply of new housing while total demand is equal to δD^h . In steady-state equilibrium, prices clear the housing market:

Lemma 2. *Let $\delta < \frac{(\phi+\beta)}{(1+\beta)}$. Under this condition, the steady-state equilibrium price of housing is:*

$$P_h^* = \left(\frac{\alpha}{B(1-\alpha)} \right) \left(\frac{(1-\pi)\beta + 1 - \frac{\sigma}{1+\sigma}\pi}{[(1+\beta) - (\phi+\beta)\delta](1-\pi)} \right) \quad (85)$$

A higher money growth rate lowers the price of housing. Further, this impact is stronger if liquidity risk in the economy is higher.

Presumably, the lower price of housing in response to higher inflation reflects an increase in housing supply. In order to sort this out, I turn to the following:

Proposition 2. *Let $\delta < \frac{(\phi+\beta)}{(1+\beta)}$. Under this condition, the steady-state stocks of capital across sectors are:*

$$K^* = \left(\frac{A\alpha [(1+\beta) - (\phi+\beta)\delta] (1-\pi)}{(1-\pi)\beta + 1 - \frac{\sigma}{1+\sigma}\pi} \right)^{\frac{1}{1-\alpha}} \quad (86)$$

$$\begin{aligned} K^{h*} = & \frac{(\phi+\beta)}{(1+\beta)} \left(\frac{\delta}{BP_h^*} \right) [A\alpha (K^*)^\alpha - BP_h^* K^*] + \\ & \left(\frac{(\phi+\beta)\delta A(1-\alpha)}{(1+\beta)} \right) \left(\frac{(1-\pi)(1+\beta)}{(1-\pi)\beta + 1} \right) \left(\frac{(1-\pi)(1+\beta)}{(1-\pi)\beta + 1 - \frac{\sigma}{1+\sigma}\pi} \right) (K^*)^\alpha \end{aligned} \quad (87)$$

Proposition 2 demonstrates how monetary intervention in the economy dramatically changes how housing market activity depends on macroeconomic conditions. In the absence of transfers from seigniorage, (61) is simply the residual amount of capital after non-residential investment. However, (87) is clearly non-linear in the non-residential stock and housing prices. In this manner, my framework demonstrates that policy intervention by monetary authorities is likely to make the interplay between the housing market and macroeconomic activity much less transparent.

Nevertheless, analytical solutions for all variables are obtainable in the special case in which the non-residential sector is equally capital and labor-intensive:

Lemma 3. *Let $\alpha = 1/2$. Assuming Proposition 1 holds, a (non-degenerate) steady-state equilibrium exists. In the steady-state, the equilibrium stocks of residential and non-residential capital are:*

$$K^* = \left(\frac{A^2}{4} \right) \left(\left(\frac{(1-\pi)((1+\beta) - (\phi+\beta)\delta)}{1 + (1-\pi)\beta - \frac{\sigma}{1+\sigma}\pi} \right) \right)^2 \quad (88)$$

$$K^{h*} = \left(\frac{\delta(\phi+\beta)}{(1+\beta) - \delta(\phi+\beta)} \right) K^* \quad (89)$$

As previously mentioned, Ahmed and Rogers (2000) find evidence of a long-run Tobin effect for the United States. It is clear from (88) and (89) that higher rates of inflation stimulate investment activity in both sectors of the economy. However, where does monetary policy have the biggest impact? I turn to this issue in the following corollary to Lemma 3:

3.2.1 The Effects of Monetary Policy

The principal objective of this section is to focus on the effects of monetary policy. Based upon Lemma 3, it is easy to see that the effects of monetary policy in the housing sector are proportional to the effects of policy in the non-residential sector:

$$\frac{\partial K^{h*}}{\partial \sigma} = \left(\frac{\delta(\phi+\beta)}{(1+\beta) - \delta(\phi+\beta)} \right) \frac{\partial K^*}{\partial \sigma} \quad (90)$$

Corollary 1. *Assume that the conditions in Lemma 3 hold. Further, let $\delta > \frac{(1+\beta)}{2(\phi+\beta)}$. If these conditions hold, $\frac{\partial K^{h*}}{\partial \sigma} > \frac{\partial K^*}{\partial \sigma} > 0$.*

According to the corollary, monetary policy will have asymmetric effects on the residential and physical capital stocks. In particular, as observed in the empirical evidence, inflation has a stronger effect on the residential capital stock than the physical capital stock. Thus, monetary policy plays a bigger role in investment in the housing sector than the non-residential sector. It is often argued that the reason for such behavior is due to the interest-rate sensitivity of the housing sector. Alternatively, the mortgage-interest deductibility through taxes is often cited. However, my framework demonstrates that the durability of the

housing stock is a significant factor. Simply put, housing is a durable asset. As a result, inflation promotes the asset with the highest present discounted stream of income. Arnott (1980) also stresses that the durability of housing should be an important consideration when evaluating the effects of public policy.

While Corollary 1 demonstrates that the effects of monetary policy are stronger in the housing sector than the non-residential sector, the following focuses on conditions in the non-residential sector:

Corollary 2. *Assume that the conditions in Lemma 3 hold. The physical capital locus, (88), behaves such that:*

$$\frac{\partial K}{\partial \sigma} > 0, \frac{\partial^2 K}{\partial \sigma \partial A} > 0, \frac{\partial^2 K}{\partial \sigma \partial \phi} < 0$$

While Corollary 1 demonstrates that inflation promotes capital accumulation, Corollary 2 demonstrates that the effects of policy are stronger if productivity in the economy is higher. However, the effects of inflation are weaker if preferences for housing are higher. Yet, my principal motivation is to study the impact of policy on housing market activity in general equilibrium:

Corollary 3. *Assume that the conditions in Lemma 3 hold. The equation denoting the residential capital stock, (89), behaves as follows:*

$$\frac{\partial K^h}{\partial \sigma} > 0, \frac{\partial^2 K^h}{\partial \sigma \partial A} > 0, \frac{\partial^2 K^h}{\partial \sigma \partial \pi} > 0, \frac{\partial^2 K^h}{\partial \sigma \partial \phi} > 0 \text{ if } \phi < \frac{(1 + \beta)(1 - \pi) - 2\delta\beta}{2\delta} \quad (91)$$

Inflation raises the residential capital stock by way of increasing the income of young workers. The revenues from the inflation tax are also higher if wages are higher which explains the complementarity between monetary policy and productivity. Thus, the model demonstrates that monetary policy would be less effective in promoting housing market activity in periods of low productivity than high productivity. For example, attempts to promote economic activity during the productivity slowdown of the 1970s were largely unsuccessful. However, residential investment was consistently higher during the high levels of productivity

encountered in the “New Economy” from 1993 - 2003. The latter period has also been characterized as a period in which homeownership rates climbed. For example, in 1970, the U.S. Census reports that the homeownership rate was 62.9%. It climbed to 64.2% in 1990 and 66.2% in 2000. The apparent increase in preferences for homeownership also contributed to the strong impact of policy on housing market activity.

I next turn to the impact on policy on consumption.

Steady-State Consumption:

$$c^{m*} = \frac{A^2 [(1 + \beta) - (\phi + \beta)\delta] (1 - \pi)}{4 \left[(1 - \pi)\beta + 1 - \frac{\sigma}{1 + \sigma}\pi \right]^2} \quad (92)$$

$$c_1^{n*} = \frac{A^2(1 - \phi)}{4 \left[(1 - \pi)\beta + 1 - \frac{\sigma}{1 + \sigma}\pi \right]} \quad (93)$$

$$c_2^{n*} = \frac{A^2(1 - \delta)(\phi + \beta)}{4 \left[(1 - \pi)\beta + 1 - \frac{\sigma}{1 + \sigma}\pi \right]} \quad (94)$$

As in the previous section, I am particularly interested in finding the determinants of the MPC from housing wealth. In contrast to the benchmark model, monetary policy has real effects on the housing market:

$$\frac{\partial(P_h h)}{\partial\sigma} = \frac{-\pi A^2(\phi + \beta)}{4(1 + \sigma)^2 \left[(1 - \pi)\beta + 1 - \frac{\sigma}{1 + \sigma}\pi \right]^2} \quad (95)$$

That is, although monetary policy leads to an increase in residential investment, the increase in supply lowers the total value of the housing stock. I next turn to the effects of policy on consumption across the consumption path:

$$\frac{\partial c_1^{n*}}{\partial \sigma} = \frac{-\pi A^2(1-\phi)}{4(1+\sigma)^2 \left[(1-\pi)\beta + 1 - \frac{\sigma}{1+\sigma}\pi \right]^2} \quad (96)$$

$$\frac{\partial c_2^{n*}}{\partial \sigma} = \frac{-\pi A^2(1-\delta)(\phi+\beta)}{4(1+\sigma)^2 \left[(1-\pi)\beta + 1 - \frac{\sigma}{1+\sigma}\pi \right]^2} \quad (97)$$

By inducing individuals to allocate more income towards housing, consumption declines. However, the marginal propensity to consume out of housing wealth remains the same as the benchmark model:

$$MPC = \frac{1 + \beta - \delta(\phi + \beta)}{(\phi + \beta)} \quad (98)$$

Moreover, the MPC is the same regardless of whether housing wealth is driven by real factors such as productivity or nominal factors such as monetary policy. This is an important argument that policymakers need to consider when trying to understand how consumption patterns respond to changes in housing market activity over time.

4 The Economy with Government Bonds

In recent years, the line between fiscal policy and monetary policy has become blurred as many have argued that the high amount of money growth that has occurred across countries simply represents a redistribution to fiscal authorities. In order to consider this possibility, I extend the model to account for inflation-financed government bonds as in Schreft and Smith (1997, 1998). In this manner, there is another asset for banks to add to their portfolios. As in the previous setting with transfers from seigniorage, monetary policy in this setting is not super-neutral.

With the introduction of government debt, banks now allocate deposits between money, physical capital, residential capital, and bonds. The real per capita bond supply is $b_t \equiv \frac{B_t}{P_t}$, and the real return on bonds is

$R_t = I_t \left(\frac{P_t}{P_{t+1}} \right)$, where I_t is the nominal interest rate. I assume there are no government transfers or taxes. Therefore, the government budget constraint requires:

$$R_{t-1}b_{t-1} = \frac{(M_t - M_{t-1})}{P_t} + b_t \quad (99)$$

Government revenue must be sufficient to cover interest payments on previously issued bonds. Revenues come from newly issued bonds along with seigniorage.

Given the bank now has four asset choices, the bank's balance sheet is:

$$w_t = m_t + i_t + i_t^h + b_t \quad (100)$$

The return paid to movers comes from the bank's money balances:

$$\pi r_t^m w_t = m_t \left(\frac{P_t}{P_{t+1}} \right) \quad (101)$$

In comparison, the return to non-movers is paid from the bank's return on physical capital investment, residential investment, and bond holdings.

$$(1 - \pi)r_t^n w_t = i_t \rho + i_t^h r + R_t b_t \quad (102)$$

The bank's objective is to maximize the expected utility of its depositors. In order for banks to invest in both types of capital and government bonds, the following two no-arbitrage conditions must hold:

$$P_{h,t}B = A\alpha K_t^{\alpha-1} \quad (103)$$

$$\frac{I_t}{\sigma} = P_{h,t}B \quad (104)$$

As in the benchmark model, money demand is:

$$m_t = \frac{\pi w_t}{(1 - \pi)(1 - \beta) + \pi} \quad (105)$$

4.1 Steady-State General Equilibrium

By virtue of the no-arbitrage conditions which apply, the total demand for housing is the return on income after money balances:

$$D^h = \frac{(\phi + \beta)}{(1 + \beta)} \frac{1}{P_h} (w - m)r \quad (106)$$

In the steady-state, bond demand is:

$$b = \left(\frac{\sigma - 1}{I - \sigma} \right) m \quad (107)$$

Similar to the previous model, in equilibrium the supply of housing must equal the total demand for housing:

$$BK^h = \delta D^h \quad (108)$$

A steady-state equilibrium reduces to two conditions on the residential capital stock and the nominal return to bonds which must hold. The first condition derives from the government's budget constraint (*GBC*):

Proposition 3. (Government Budget Constraint) *Suppose that $\frac{\alpha}{(1-\alpha)(1-\pi)} > \frac{I}{\sigma}$. Also, assume that $I < \sigma$. Under these conditions, the residential capital stock is positive and described by:*

$$K^h = A(1 - \alpha) \left(\frac{A\alpha\sigma}{I} \right)^{\frac{\alpha}{1-\alpha}} \left(\frac{(1 - \pi)(1 - \beta) - \frac{(\sigma-1)}{(I-\sigma)}\pi}{(1 - \pi)(1 - \beta) + \pi} \right) - \left(\frac{A\alpha\sigma}{I} \right)^{\frac{1}{1-\alpha}} \quad (109)$$

In addition, $\frac{\partial K^h}{\partial I} |_{109} > 0$ and $\frac{\partial K^h}{\partial \sigma} |_{109} > 0$.

In equilibrium I am interested in analyzing the economy when $I > 1$. This insures that the return on money is dominated by the return from other assets. However, as $I < \sigma$, this implies that the revenues earned from money creation exceed the interest paid on government bonds. Hence, $b < 0$. That is, the residential capital stock only exists as long as the government is a net lender to the financial system.

Typically, in models such as Schreft and Smith (1997, 1998), the government budget constraint has two potential positions. If $I > \sigma$, the government is a net borrower since the interest to pay for its debt exceeds seigniorage revenues. The other position is similar to the result in Proposition 3. In the presence of government bonds, residential investment competes with bonds and the non-residential sector for resources. As suggested by the Proposition, if the government were a net borrower, it would require the housing stock to be negative. In contrast, a higher money growth rate provides the fiscal authority with more resources to support housing market activity.

The second condition that must hold is that the housing market must be in equilibrium:

Proposition 4. (Housing Market Equilibrium) *The relationship between I and K^h in which (108) is satisfied is described by:*

$$K^h = \left(\frac{(\phi + \beta)\delta}{(1 + \beta)} \right) A(1 - \alpha) \left(\frac{A\alpha\sigma}{I} \right)^{\frac{\alpha}{1-\alpha}} \left(\frac{(1 - \pi)(1 - \beta)}{(1 - \pi)(1 - \beta) + \pi} \right) \quad (110)$$

In addition, $\frac{\partial K^h}{\partial I} |_{110} < 0$ and $\frac{\partial K^h}{\partial \sigma} |_{110} > 0$.

Steady-state locus, (110), represents equilibrium in the housing market. More specifically, (110) demonstrates how the nominal interest rate must relate to residential capital to ensure the demand for housing is

equivalent to the supply of housing. As demonstrated by the Proposition, there is a negative relationship between the nominal interest rate and the residential capital stock. At higher nominal interest rates, the return to government bonds is higher. As a result, banks allocate more resources to bonds which results in lower residential investment. However, higher money growth reduces the real return to bonds and induces a substitution towards residential capital.

Based upon the above analysis, I arrive to the following Proposition:

Proposition 5. *Suppose that $\left(\frac{\phi+\beta}{1+\beta}\right) A > (1-\pi) + \frac{\pi}{1-\beta}$ as $I \rightarrow \infty$ and $\left(\frac{\phi+\beta}{1+\beta}\right) \delta(1-\beta) + \frac{\alpha\sigma[(1-\pi)(1-\beta)+\pi]}{(1-\alpha)} < (1-\pi)(1-\beta) + \pi$ as $I \rightarrow 1$. If these conditions hold, a unique steady-state exists in which $I < \sigma$.*

Figure 2 depicts the Government Budget Constraint and Housing Market Equilibrium loci in which an equilibrium exists.

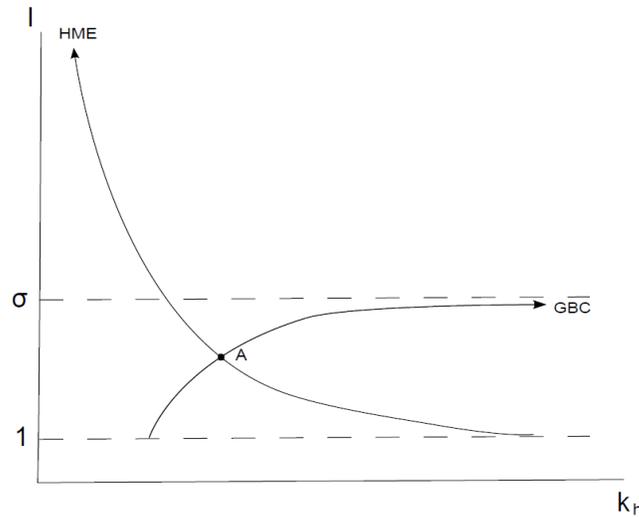


Figure 2: Steady-State Equilibrium

In the following, I discuss the effects of monetary policy in the presence of government bonds.

4.1.1 The Effects of Monetary Policy

I now focus on the effect of monetary policy on the residential capital stock. As opposed to Schreft and Smith (1997, 1998), only one steady-state exists so the effects of monetary policy on capital accumulation can be pinned down.

To begin, as previously mentioned in Proposition 3, a higher money growth rate shifts the locus (109) to the right. I refer to this shift as the *redistribution effect from monetary policy* as it is associated with the bank's allocation from nominal to illiquid assets and thereby induces redistribution from movers to non-movers when residential investment increases.

From Proposition 4, a higher rate of inflation also shifts the locus associated with (110) to the right. This reflects the *substitution effect from monetary policy* as inflation reduces the real return to government bonds. Consequently, banks allocate more funds towards residential investment.

The total increase in residential investment due to both mechanisms is shown in Figure 3 below:

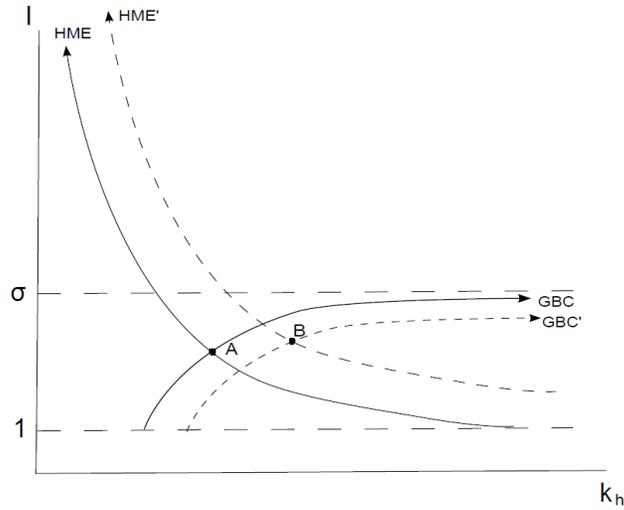


Figure 3: Increase in the Rate of Money Growth

5 Optimal Monetary Policy

The previous two sections provide mechanisms in which inflation promotes housing market activity. In fact, each model shows that the impact of inflation is *permanent* – that is, higher inflation rates promote investment and housing market activity from *any* inflation rate. However, the U.S. inflationary experience in the 70s shows that there are limits to the potential benefits from higher inflation. For example, Bernanke

(2004) contends that high inflation contributed to output volatility and high unemployment during the 1970s. Romer and Romer (2002) make the same arguments.

I incorporate the relationship between volatility and risk observed in the data by assuming that the incidence of liquidity risk is a function of monetary policy, $\pi(\sigma)$. In particular, I posit that the marginal increase in risk is higher at high inflation rates. Therefore, I consider the case where $\pi(\sigma) = \pi(1 + d\sigma)^2$. Similar ideas have been proposed in the literature. For example, Ghossoub and Reed (2010) study a model in which the incidence of liquidity risk is a function of the capital stock. They argue that such a mechanism captures the increased exposure to risk in poor countries relative to the stability of advanced economies.

My objective is to show that introducing the relationship between policy and volatility allows us to formalize the trade-offs inherent in designing policy to stimulate housing market activity. In particular, I demonstrate that these trade-offs are important for thinking about how optimal monetary policy depends on conditions in the housing market. To show the impact of policy, I return to a setting in which seigniorage revenues are transferred to the young. I define welfare as the expected lifetime utility of an individual young agent:

$$U(c_{t+1}^m, c_{t+1}^n, h_{t+1}, c_{t+2}) = \pi(\sigma) \ln(c_{t+1}^m) + (1 - \pi(\sigma)) [\phi \ln(h_{t+1}) + (1 - \phi) \ln(c_{t+1}^n) + \beta \ln(c_{t+2}^n)]$$

I characterize “optimal” monetary policy by the choice of σ that would maximize welfare.

In terms of my numerical analysis, I start by identifying the optimal rate of inflation given my choice of parameters. I consider the following parameter set: $A = 7.4$, $B = 4.8$, $\beta = .8$, $\delta = .33$, $\alpha = .5$, $d = 9.7$, $\pi = .35$, and $\phi = .3$. Also, in order to maintain consistency with the majority of the previous analytical results, I assume that the non-residential sector is equally capital and labor-intensive. The primary point of my parameter set is that the welfare-maximizing rate of inflation is $\sigma^* = 0.03$. This is demonstrated in Table 1 below and is consistent with the average inflation rates during the Volcker-Greenspan era of monetary policy, the “Great Moderation.”

Table 1

Optimal monetary policy

	0.015	0.02	0.025	0.03	0.035	0.04	0.045
σ							
K^h	1.74612	1.74883	1.75119	1.75319	1.75484	1.75614	1.75708
K	3.87525	3.87613	3.87472	3.87104	3.86507	3.85684	3.84635
m	1.68726	1.69275	1.69871	1.70517	1.7121	1.71953	1.72744
w	7.28369	7.28452	7.2832	7.27973	7.27412	7.26637	7.25648
P_h	.391571	.391527	.391598	.391784	.392086	.392504	.39304
h	25.3981	25.4376	25.4719	25.501	25.525	25.5438	25.5576
τ	.0249349	.0331911	.041432	.049665	.0578972	.0661356	.0743872
$P_h * h$	6.45678	6.46015	6.46241	6.46355	6.46358	6.46249	6.46028
<i>welfare</i>	3.00459	3.00553	3.00607	3.0062	3.00593	3.00526	3.00419

In comparison to the model with transfers, higher rates of inflation promote residential investment but not investment in the non-residential sector. However, higher inflation rates are associated with higher housing prices which is consistent with available evidence.

I turn to examining the role that housing market fundamentals play in determining optimal monetary policy. I begin with a setting in which productivity in the housing sector is lower ($B = 2.4$). This may be due to increased land regulations over time. The results are listed in Table 2:

Table 2Optimal monetary policy ($B = 2.4$)

σ	0.024	0.027	0.03	0.033	0.036	0.039	0.042
K^h	1.75075	1.75204	1.75319	1.75423	1.75513	1.75591	1.75656
K	3.87519	3.87352	3.87104	3.86733	3.86361	3.85867	3.85292
m	1.69748	1.70124	1.70517	1.70927	1.71355	1.718	1.72263
w	7.283149	7.28207	7.27973	7.27662	7.27274	7.26809	7.26267
P_h	.783149	.783317	.783568	.783903	.784321	.784823	.785409
h	12.7327	12.7421	12.7505	12.758	12.7646	12.7702	12.775
τ	.0397847	.0447258	.049665	.054604	.0595442	.0644871	.0694343
$P_h * h$	6.46205	6.463	6.46355	6.4637	6.46345	6.46279	6.46172
<i>welfare</i>	2.87123	2.87152	2.87167	2.87169	2.87158	2.87133	2.87096

In response to the lower productivity, supply in the housing market will be lower. Consequently, access to housing would be lower. In order to promote housing market activity, the optimal rate of money growth is raised to $\sigma^* = 0.033$. As a result, residential investment will increase and promote housing supply in the face of low productivity. In this manner, optimal monetary intervention should be more aggressive in economies with adverse housing supply conditions.

I conclude by looking at a setting in which there is an increase in housing demand. This is due to the higher consumption-value of home ownership:

Table 3Optimal monetary policy ($\phi = .5$)

	0.01	0.015	0.02	0.025	0.03	0.035	0.04
σ							
K^h	1.89136	1.89454	1.89726	1.89953	1.9013	1.9027	1.90362
K	3.26419	3.26631	3.26627	3.26409	3.25976	3.25329	3.24468
m	1.54456	1.54903	1.55389	1.55912	1.56475	1.57077	1.57717
w	6.68482	6.68698	6.68695	6.68471	6.68028	6.67364	6.66481
P_h	.426651	.426513	.426515	.426658	.426941	.427365	.427932
h	27.5106	27.5569	27.5965	27.6295	27.6559	27.6757	27.689
τ	.0152927	.0228921	.0304683	.0380274	.0455753	.053178	.0606604
$P_h * h$	7.62535	7.63071	7.63472	7.6374	7.63875	7.63877	7.63748
<i>welfare</i>	3.15788	3.15907	3.15972	3.15985	3.15944	3.15852	3.15706

If individuals value homeownership more, the optimal monetary policy rule seeks to reduce volatility in the economy. This promotes the ability of individuals to save so that they face less exposure to liquidity risk. As a result, the optimal rate of inflation falls to $\sigma^* = 0.025$. That is to say, monetary policy should be more conservative if fundamentals in the economy favor housing demand.

6 Conclusion

In recent years, the impact of monetary policy on housing markets and the macroeconomy has received a large amount of attention. This paper provides a dynamic general equilibrium model with a microfoundation for money to study the transmission of monetary policy to the housing sector and macroeconomic activity. While previous empirical work has shown that inflation stimulates housing sector activity, my research develops a rich framework to show that there are important asymmetries resulting from monetary stimulus. As in a large volume of work on housing, I show that the durability of housing as an asset plays a huge role. Moreover, I study how optimal policy intervention depends on conditions in the housing sector. Interestingly, I find that optimal money growth is higher if productivity in the residential sector is low. In this manner, I

argue that policy should be designed according to supply conditions in the housing sector. By comparison, inflation should be lower when conditions favor housing demand.

There are a number of issues I intend to address in future work. For example, the model could be extended as in Arnott et al. (1999) to study the impact of monetary policy on investment in both housing quantity and quality. Investment in multi-family structures could also be incorporated. In addition, both Arnott and Braid (1997) and Harding et al. (2007) look at housing maintenance and depreciation over time. One could also use my framework to show how inflation plays a role in housing sector activity through endogenous maintenance expenditures. Finally, Mankiw and Weil (1989) point out that population demographics have important consequences for housing prices. Consequently, I intend to study how optimal monetary intervention depends on demographics in future work.

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Chapter 3: Monetary Policy and Housing Market Activity: A Sign Restriction Approach

1 Introduction

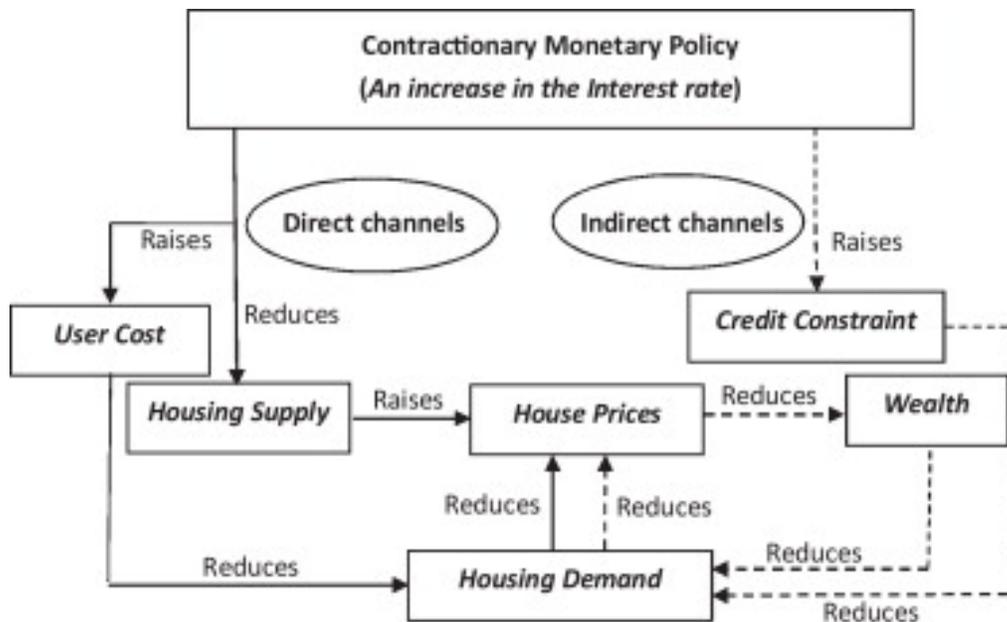
The recent financial crisis in the US has invigorated the debate about the effects of the housing market on the macro economy and about how monetary policy should respond to housing market conditions. Some have argued that monetary policy contributed to the housing boom that led to the collapse in housing prices. For instance, Taylor (2007) shows that low interest rates may have contributed to the boom in housing starts, which may have driven housing prices upward.

Defined as the total value of residential capital, housing wealth made up approximately 35% of total household net worth in 2012. Furthermore, housing is the primary source of wealth accumulation for most Americans, thus, fluctuations to housing wealth will transmit to GDP as shown by Case, Quigley and Shiller (2005), Carroll, Otsuka and Slacalek (2006) and Campbell and Cocco (2007) .

The significance of housing extends beyond wealth accumulation. Over the business cycle, fluctuations in residential investment are known to lead GDP (Leamer, 2007). Moreover, residential investment, an indicator of housing wealth, is the most volatile component of GDP. According to Wheaton (2010), residential investment added over 0.4 percentage points per year to GDP growth between 1993 and 2005. Even more, from 2006 to 2009 residential investment subtracted roughly 1 percent from annual GDP growth.

As a result of housing's influence on economic activity, understanding the link between monetary policy and the residential sector is of considerable importance. In comparison to other sectors of the economy, the impact of monetary policy on housing is far more pervasive due to the interest-sensitivity of housing. Through higher or lower interest rates, monetary policy can significantly affect the housing market, and in turn the overall economy, directly or indirectly through a number of channels. Monetary policy directly impacts the user cost of capital and housing supply, while indirectly affecting housing wealth and credit constraints. Figure 1 provides a graphical explanation of how contractionary monetary policy impacts housing activity.¹⁴

¹⁴Figure 1 was taken from Wadud, Bashar, and Ahmed 2012.



Monetary Transmission Channels and Housing Market Activity

The objective of this paper is to estimate the effects of a monetary policy shock on housing market activity in the US. More specifically, I estimate the responses of residential investment, housing starts, residential building permits and single-family houses sold to an unanticipated contractionary monetary policy shock. The methodology adopted here is vector autoregression (VAR) analysis.

VAR models are widely used to analyze monetary policy, however, identifying a monetary policy shock is a fundamental concern. The literature has provided a number of different identification schemes: informal identifying restrictions, partial identification, agnostic identification and tentative identification. Typically, researchers adopt a specific informational ordering of the variables to identify a monetary policy shock. In addition, implicit assumptions are used to establish "reasonable" results. For instance, a reasonable response to a monetary expansion would be an increase in output and prices along with a decrease in the federal funds rate. If this does not occur researchers characterize the findings as a puzzle.

Following the work of Uhlig (2005) I use the sign-restriction approach to identify a contractionary monetary policy shock. Here, identifying a monetary policy shock does not depend on the informational ordering of the arriving shocks. Instead, I identify a monetary policy shock by explicitly imposing sign-restrictions on the impulse response vectors. More specifically, I assume the federal funds rate is non-decreasing, and

output, prices, nonborrowed reserves and total reserves are non-increasing. I do not impose any restrictions on the variables of interest. That is to say, the housing variables are left agnostically open.

The horizon at which the restrictions are imposed is determined by the researcher. As a result, different researchers use different time horizons. For example, Uhlig (2005) uses a number of different restriction horizons ranging from 3 to 24 months. As one might expect, the longer the restrictions are in place the longer the shock will last. The restrictions I impose hold for 5 periods (quarters), which equates to fifteen months.

Similar to the method adopted here, a number of others in the literature have imposed explicit restrictions on impulse responses, Dwyer (1997), Canova and de Nicolo (2002) and Faust (1998). Dwyer (1997) imposes restrictions on the shape of the impulse response, while Canova and de Nicolo (2002) impose sign restrictions on the cross-correlations of variables. Faust (1998) also imposes sign restrictions to identify monetary policy shocks, although, he only imposes restrictions on impact.

The housing market's response to monetary policy shocks and money supply shocks have been studied by Wheeler and Chowdhry (1993) and Lastrapes (2002). Using the block-recursive structure, Wheeler and Chowdhry (1993) find evidence that monetary policy has a significant impact on residential investment. Lastrapes (2002) focuses on the relationship between housing and money supply shocks, and he uses a block-recursive structure with the assumption that housing variables do not impact monetary policy contemporaneously. Lastrapes finds that money supply shocks have real effects on the housing market. Moreover, he finds that real housing prices and housing sales respond positively to a positive money supply shock.

While the existing literature demonstrates that monetary policy does impact the housing market, the identification method used here is vastly different from the block-recursive structure previously used. The agnostic approach adopted in this paper imposes no restrictions on the responses of the housing variables.

Again, this study focuses on the impact of a contractionary monetary policy shock on housing market activity, as represented by residential investment, housing starts, residential building permits and single-family houses sold. I find that residential investment declines by 1% as a result of a contractionary monetary policy shock, and two years after the shock residential investment increases. The observed reversal in the housing sector reflects a policy change by the Federal Reserve Bank.

The remainder of the paper is as follows: Section 2 describes the data used for this analysis. In Section 3 the methodology is outlined. Section 4 examines the identification method. Section 5 presents the impulse

response functions with detail. The final section is the conclusion.

2 Data

I use quarterly data covering the period 1975Q1-2004Q4 to conduct my analysis. Staying consistent with the literature, my data does not include the financial crisis period. I use four different variables to measure housing market activity: new privately owned housing units started, new private housing units authorized by building permits, new one family houses sold and real private residential fixed investment.

Data on new privately owned housing units started (housing starts), new private housing units authorized by building permits (residential building permits) and new one family houses sold (single-family houses sold) are obtained from the U.S. Census Bureau. Measures for housing starts and single-family houses sold are constructed using data from the Survey of Construction (SOC). The SOC reports monthly estimates on each variable. The U.S. Census Bureau uses data from the Building Permits Survey (BPS) to produce the residential building permits variable. The BPS is a monthly survey of 9,000 selected places issuing building permits for privately-owned residential structures.

The fourth housing variable is real private residential fixed investment (residential investment), which comes from the U.S. Bureau of Economic Analysis. This measure includes all private residential structures and residential equipment rented to tenants. Residential structures include new construction of single-family and multi-family housing, spending on manufactured homes, realtor commissions, improvements to housing units and net purchases of used structures from government agencies.

I obtain data on Real GDP and the GDP Deflator from the U.S. Department of Commerce (BEA), while data on the commodity price index (Dow Jones Spot Average) was obtained from Global Financial Data. The national house price index comes from the Federal Housing Finance Agency. Finally, data on non-borrowed reserves, total reserves and the federal funds rate are retrieved from the Board of Governors of the Federal Reserve System.

3 Methodology

The methodology adopted for this paper mimics the work of Fry and Pagan (2011). The procedure used is the VAR model, which is useful for tracking all dynamic interactions between variables. Impulse response functions (IRFs) are used to determine how the variables of interest respond to an identified monetary policy shock. The structural VAR model is represented by the following notation:

$$BY_t = A(L)Y_{t-1} + \varepsilon_t, \varepsilon_t \sim N(0, \Sigma_\varepsilon) \quad (111)$$

B contains the coefficients reflecting the relationship between each endogenous variable, $A(L) = A_1L + \dots + A_pL$ is the lag polynomial, and ε_t is the $n \times 1$ vector of structural shocks. I estimate four different models; each model includes one of the housing variables in conjunction with real GDP, the GDP deflator, the federal funds rate, the commodity price index, a housing price index, nonborrowed reserves and total reserves. All variables enter the system in log form, with the exception of the federal funds rate. Using the Akaike information criteria I select a lag length of two.

The model must be estimated in its reduced form, which has the following representation:

$$\begin{aligned} Y_t &= \Pi(L)Y_{t-1} + e_t, e_t \sim N(0, \Sigma_e) \\ \Pi(L) &= B^{-1}A(L) \end{aligned} \quad (112)$$

OLS is used to estimate the reduced form model. Using the residual values from OLS along with knowing the relationship between the structural shocks and the VAR errors, $e_t = B^{-1}\varepsilon_t$, I can estimate the matrix B^{-1} by decomposing the variance covariance matrix:

$$\Sigma_e = PVP' = \tilde{P}\tilde{P}'. \quad (113)$$

The matrix V contains the diagonal eigenvalues and P contains the eigenvectors. This decomposition can be rewritten as such:

$$\Sigma_e = \tilde{P}Q Q' \tilde{P}' \quad (114)$$

where Q is an orthonormal matrix with $QQ' = Q'Q = I$. The matrix Q , which contains the structural shocks, is selected using Givens rotations. An n variable system produces $\binom{n}{2}$ rotations and each Givens rotation is multiplied to produced a $n \times n$ Givens matrix. For this paper $n = 8$, however, for simplicity assume $n = 3$ and the Q matrix is as follows:

$$Q = \begin{bmatrix} \cos(\theta_1) & -\sin(\theta_1) & 0 \\ \sin(\theta_1) & \cos(\theta_1) & 0 \\ 0 & 0 & 1 \end{bmatrix} * \begin{bmatrix} \cos(\theta_2) & 0 & \sin(\theta_2) \\ 0 & 1 & 0 \\ -\sin(\theta_2) & 0 & \cos(\theta_2) \end{bmatrix} * \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos(\theta_3) & -\sin(\theta_3) \\ 0 & \sin(\theta_3) & \cos(\theta_3) \end{bmatrix} \quad (115)$$

with θ_1 , θ_2 , and θ_3 representing the rotation angels, which are drawn from a uniform $[0, \pi]$ distribution. The givens matrix Q is orthogonal so multiplying uncorrelated structural shocks with Q will yield structural shocks that are uncorrelated. Impulse response functions are constructed with each draw from the rotation matrix. If the responses of the variable to the shocks have the correct sign for the appropriate length of time then the responses are kept, otherwise they are discarded. I use the 1000 kept draws to select the best structural model and impulse response functions. Following Fry and Pagan (2011), the median target method is used to determine which impulse responses to present. The method involves minimizing a distance criterion from the median impulse responses, and then selecting the impulse responses closest to the median values. The error bands are computed using the 1000 kept impulse responses. I report the impulse responses along with the 84th and 16th percentile confidence bands.

4 Identification

Similar to Faust (1998), Canova and de Nicolo (2002) and Uhlig (2005), I use the sign restriction approach to identify a monetary policy shock. In other words, I impose explicit restrictions on the impulse responses of certain variables in the system. A contractionary monetary policy shock is identified when the responses of prices, output (real GDP), non-borrowed reserves and total reserves are non-increasing and the response of the federal funds rate is non-decreasing. These restrictions hold for 5 periods, which is equivalent to fifteen months, and I do not impose any restrictions on the housing variables. For example, a monetary policy shock follows the following pattern:

Variable	real GDP	GDP deflator	fed funds rate
Response to monetary policy shock	-	-	+

Variable	nonborrowed reserves	total reserves
Response to monetary policy shock	-	-

Variable	commodity price index	house price index
Response to monetary policy shock	-	-

Given the identification procedure, the results will be consistent with economic theory; therefore, re-specifying the model is not needed to achieve "reasonable results". As I impose the "right results" as part of my identification restrictions. Another key benefit to using the sign restriction approach as opposed to the recursive identification is that the no contemporaneous effect assumption is not required but not excluded either. In other words, the impulse responses you get from the recursive method are possible outcomes with the sign restriction approach.

5 Results

I present four sets of impulse response functions, each set contains one of the four housing variables along with the other seven variables used to identify the monetary policy shock. The top row shows the response of real GDP and nonborrowed reserves, the second row shows the response of the GDP deflator and total reserves. The third row displays responses for the commodity price index and the housing price index. The final column reveals the response of the federal funds rate and the variable of interest. Figures 1 - 4 show impulse responses for up to 15 years after the shock; however, I will only discuss the dynamics for up to 5 years after the shock.

According to Figure 1, real GDP declines by 0.15% immediately following the shock and gradually reverts to zero within 2.5 years after the shock. The GDP deflator dropped 0.20% within a year of the shock and declines further to 0.30% within 5 years. The commodity price index declines 1.5% a year after the shock, while the house price index falls by 0.25% over the same time period. Nonborrowed reserves drop by 1.3%

within six months of the shock, and total reserves drop 1.25% one and a half years later. The federal fund rate increases initially and then falls by 0.15% eighteen months after the shock. Residential investment declines by a large amount, 1%, within a year, but then increased by approximately 1% three years later.

There are two surprises: the response of the federal funds rate and the response of residential investment. It is somewhat unconventional to see both these variables reverse course over time. One possible explanation for the federal funds rate response, put forward by Uhlig (2005), is that monetary policy shocks arise as errors of assessment of the economic situation by the Federal Reserve Bank. If this occurs the Federal Reserve Bank will react quickly to correct the error. A more straight forward way to think about it is the Federal Reserve Bank reverses course after the shock is felt throughout the economy. As a result of the Federal Reserve Bank's policy change residential investment also changes course.

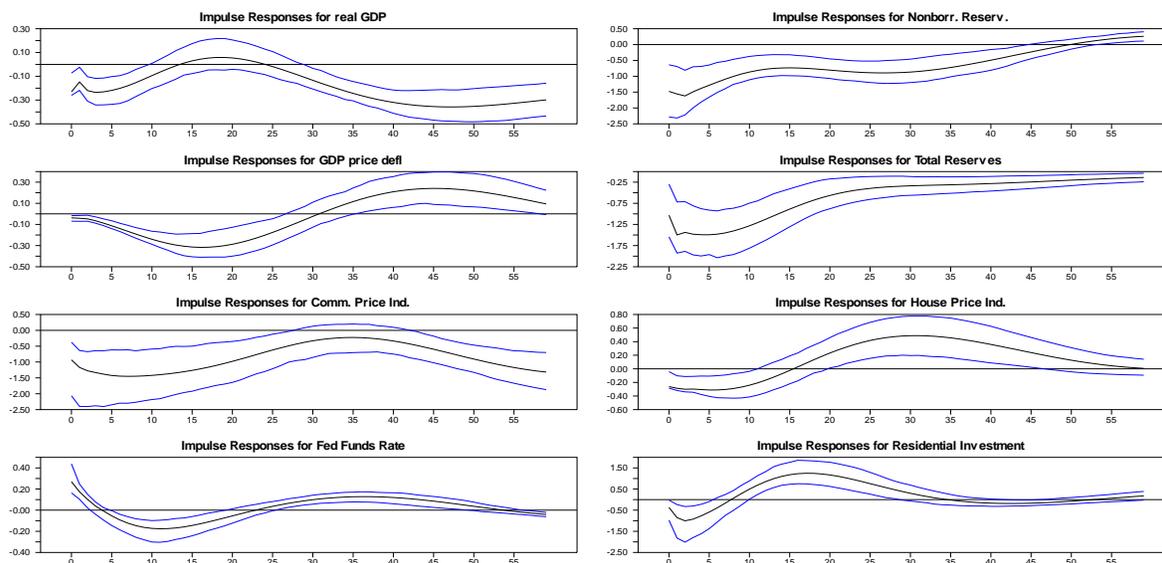


Figure 1: Impulse Responses

Row 4, column 2 of Figure 2 reveals the dynamic response of housing starts to a contractionary monetary policy shock. The immediate decrease in housing starts is insignificant; however, housing starts do increase to 0.90% approximately 3 years after the shock. Interest rates go higher initially and then fall 1 - 3 years after the shock, which explains the delayed increase in housing starts.

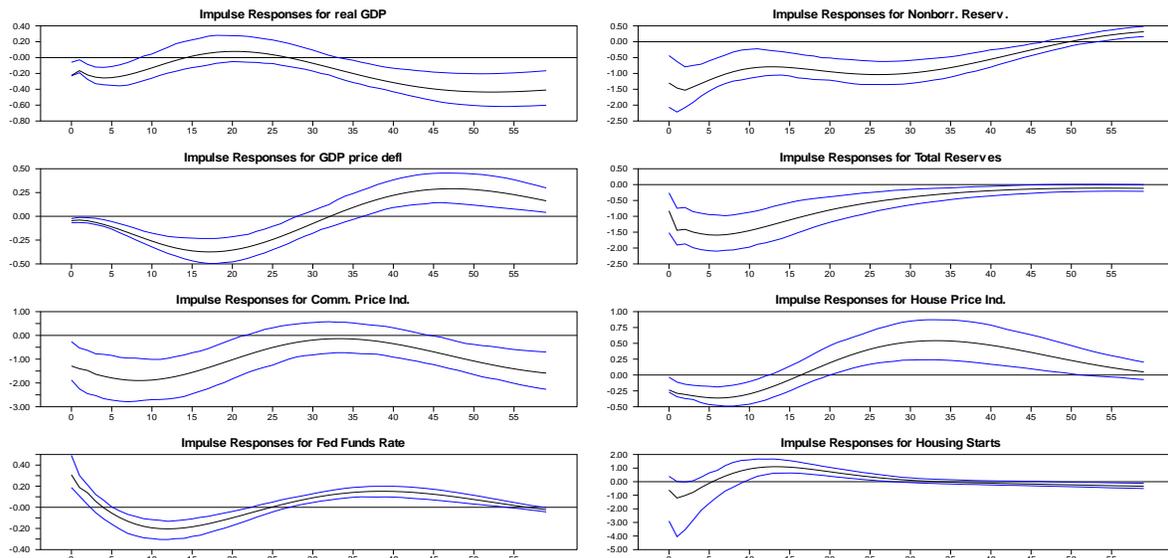


Figure 2: Impulse Responses

In Figure 3 the house price index declines immediately following the shock, but increases 5 years after the shock. New private housing permits follow a pattern similar to residential investment – decreasing by a large amount and then increasing by a large amount 3 years later.

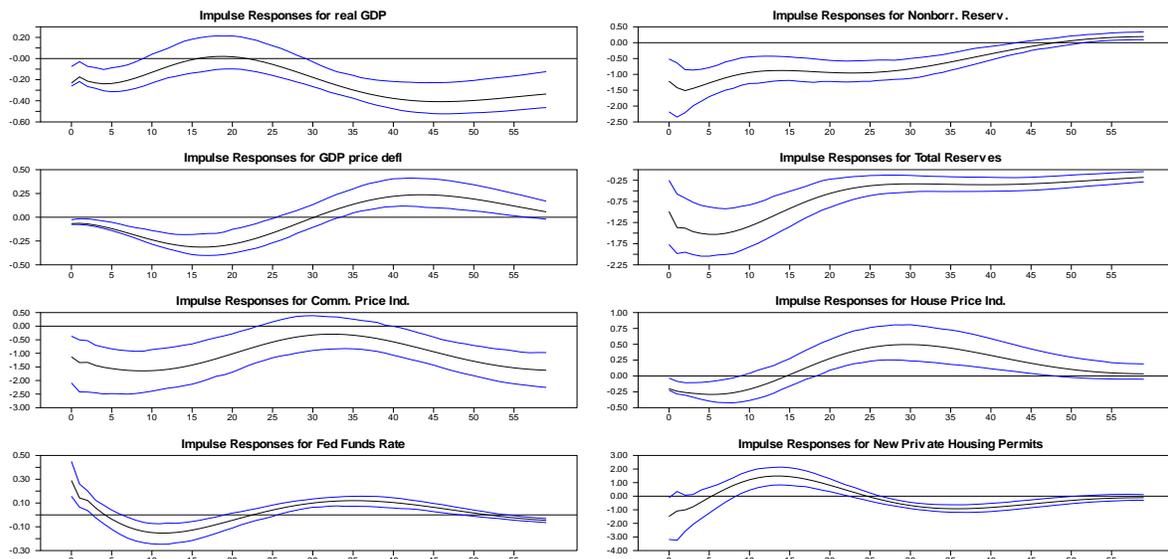


Figure 3: Impulse Responses

The final set of impulse responses contain the housing variable: single-family houses sold. Consistent with residential investment, the response of single-family houses sold reverses course; the response starts out negative and then turns positive. Again, this reversal is linked to the Federal Reserve Banks policy switch.

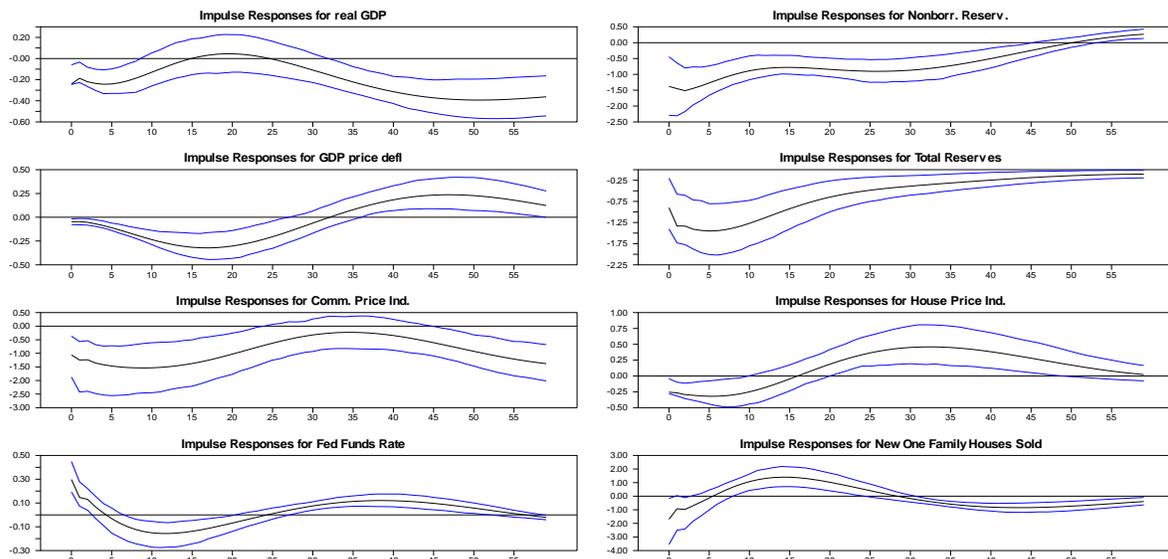


Figure 4: Impulse Responses

6 Conclusion

In summary, I find that a contractionary monetary policy shock reduces activity in the housing sector. More specifically, residential investment declines by 1% shortly after a contractionary monetary policy shock. Furthermore, housing starts, new private housing permits and new single family houses sold also decrease in response to the shock. Interestingly, each housing variable reverses course 2 - 3 years after the contractionary monetary policy shock. The reversal in the housing sector is a reflection of the actions taken by the monetary authorities. Soon after the economy contracts the Federal Reserve Bank will reverse course by lowering the federal funds rate, which stimulates activity in the housing sector.

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