Multipliers, Mark-Ups, and Mobility Rents:
In Defense of ‘Chain Models’ in Urban and Regional
Analysis

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Abstract: Social scientists have long used ‘chain’ metaphors, yet their methodological justification remains somewhat hazy. This paper offers a rationale for using chains to measure changes in economic welfare in urban and regional contexts. In contrast to the Marshallian surplus, which well describes situations in which price changes generate rents in a single market, chains are especially useful in markets where changes lead to the transmission of demand or supply through a series of markets characterized by sticky prices and mark-ups. This argument is illustrated by reference to chain-driven analyses of local production, labor and housing markets. The institutional structures that underpin chain models, are stressed.

1. Introduction

Social scientists have long used ‘chain’ metaphors to conceptualize the operation of key parts of the economy. The workings of the housing, labor and production markets have all been explained as subject to predictable linear processes whereby a change in one part of a given system elicits responses in other parts of the system. Recently we have presented an approach to labor chain modeling for use in evaluating welfare gains from economic development activities at the local level (Persky, Felsenstein, and Carlson, 2004). This model draws on a tradition of ‘chain analysis’ built by sociologists, economic geographers and regional scientists. This modeling strategy has been common in the study of housing vacancies. Demographers have used chains extensively for the study of migration patterns. Perhaps economists and regional scientists are most familiar with chains in the context of Leontief input-output tables and the related tools of impact analysis. While chains are common in social science research, their methodological justification remains somewhat hazy. The purpose of this paper is to provide rationales for when to choose and when not to choose chain approaches in urban and regional research.

Researchers’ treatment of chains can often appear mechanistic and thus further strengthen suspicions that these tools lack strong theoretical underpinnings. Chain models hardly ever build on formal maximizing behavior by individuals or firms, pay little attention to short run price changes as an allocation method, and often ignore questions of market clearing. Obviously for problems where these elements are of prime importance, chains are not going to do a very good job for either description or prescription.

Despite these issues, we maintain that chains do have a place. More than thirty years ago, White (1970, 1971) argued that chain models offered promise for describing elements of markets as diverse as those for housing, labor and second-hand cars. He emphasized the common theme of mobility in these fields and began a critique of traditional market approaches to such phenomena (White, 1970, Ch. 8 and Ch. 13) considering some eighteen model characteristics over a dozen alternative models of mobility. White's survey is a rich source of material that has been less than fully exploited in urban and regional analysis. Here, we certainly don't claim to replace or even summarize that broad survey. Rather we focus on one contrast, that between models which rely heavily on the traditional Marshallian surpluses and those which emphasize the transformation or transition of inputs. While White notes this contrast, he discusses it only briefly in his work.

The Marshallian cross provides a strong theoretical paradigm for situations in which changes generate rents for either buyers or sellers in a particular market (Marshall 1961). Chains, however, stretch across and connect markets. We suggest a basic theoretical rationale for using chain methodologies in urban, regional and planning research: *the description and welfare analysis (including distributional analysis) of changes which generate rents over a series of markets related through predictable institutional pathways*. In this approach, chain analyses are examples of general equilibrium models. However, unlike the abstract economic approach to general equilibrium, chain models emphasize structural/institutional lines of transmission. These lines of transmission work not so much through price changes, as through predictable cascades in demand or supply.

In advancing this proposition we review the major applications of chains analysis with an eye to their successes and failures. We argue that the best applications have occurred precisely when exogenous changes lead to transmission of demand or supply through a series of markets characterized by sticky prices and short-side power.¹ The worst stumbles in applying chain theory have emerged where price changes short-circuit the underlying logic of the chain approach. We illustrate chain-type applications in regional input-output, local labor market and housing market analyses. This highlights the role of mobility rather than price movements as a source of local and regional change. We conclude with a synthesis of the three archetypal uses of chain models in urban and regional analyses and emphasize the need for chain users to provide more extensive motivation for the fixed character of their price systems and transition matrices.

2. Applications of the Chain Metaphor

At the heart of the 'chain model' is the observation that a move by an individual will predictably and relatively quickly affect other parts of the system. While Harrison White's seminal book is often credited with introducing the notion of chain-reactions in diverse social systems (White 1970), the roots of the idea can be traced to early descriptive studies in the housing market literature (Firestone 1951; Kristof 1965). These spawned the housing market filtering literature that collected case study evidence from a variety of settings and tried to draw urban planning and policy conclusions as to efficient

¹ Of course, sticky prices may arise from a number of institutional structures. We find most interesting the observation that short-side power may generate sticky prices. Short-side power emerges when markets are perennially in a condition of excess demand or excess supply. The concept of short-side power has been developed by Gintis (1989).

allocation of housing for the disadvantaged. Much of this literature was concerned with non-probabilistic and data-intensive charting of real-world chains. Little attempt was made at simulating or inferring chain dynamics using probabilities. From the 1960's upto the present, this concern with filtering in housing markets has continued to sporadically occupy urban geographers and sociologists. As housing units are well-defined entities that can be identified and contacted, much of this work has taken the form of place based studies that trace vacancies through the direct surveying of households and make inferences about average chain lengths (Adams 1973, Dzus and Romsa 1977, Forrest and Murie 1994, Lansing, Clifton and Morgan.1969, Millard-Ball 2002, Watson 1974).

An alternative approach to chain analysis has taken the probabilistic route. Rather than directly mapping chains, convenient mathematical short-hand allows for the estimation of chain length based on the probability that a vacancy at a given level will be filled from a given origin state. In this approach, the properties of chains are simulated synthetically rather than identified empirically. While there are a number of variants on the probabilistic model they all simulate the way in which new vacancies are diffused through a system. The key here is that the move of a vacancy (originating in a new home or job) from one class to another (as a household or worker moves in the opposite direction) can be assigned a probability of transition. If these probabilities are stable, the response of the system to any initial set of new vacancies can be simulated. A key property of these models is that vacancy moves are determined solely by current states. This makes the model particularly appropriate for simulating moves between units or vacancies such as cars, houses, or jobs. These are devoid of accumulated feelings or choices that could affect their present state. Furthermore, all models incorporate an

absorbing state, which means all chains terminate at some point (a housing vacancy may go to a newly formed household leaving no further vacancy, or a job vacancy may go to a new entrant to the labor force leaving no opening)².

The probabilistic model has been used as the workhorse of chain-based analyses. Chain length and individual mobility within chains have been examined empirically using variants of the model in housing market analyses (Emmi and Magnusson 1994, 1995, Hua 1989, Marullo 1985, Sands 1977, White 1971), studies of occupational mobility (Emmi 1985, 1986, 1987) and residential segregation (Huff and Waldorf 1988).

Aside from matching dwellings and house buyers, the chain model has been used in other diverse social science settings as an instrument for analyzing how supply and demand conditions are coordinated and how a constant process of re-alignment between the two, takes effect. Thus it has been utilized for matching college football coaches with teams (Smith and Abbot 1983), clergy with parishes (White 1970), musicians with orchestras (Abbot and Hrycak 1990) and even hermit crabs with shells (Chase, Weissburg and DeWitt 1988). Three major subject areas however stand out in their applications of the chain metaphor.

The first relates to *labor market analysis*. Ostensibly, studies of labor market dynamics provide some of the work closest in spirit to the chain model. Starting with the much-cited work of Holt and David (1966), labor economists have used vacancies, job searching and matching functions in order to understand the vacancy-unemployment relationship in imperfect markets. This early work also stressed the demand-side dynamics of the labor market rather than emphasizing supply side characteristics. In this work, vacancies and unemployment are the stock variables, regulated by the flow

² For a more formal treatment of the model see Bartholomew (1973), Kemeny and Snell (1960).

variables such as new hires, recalls into the labor market etc. and eventually the market reaches an equilibrium state.

Building on this approach, the job flows literature further develops the vacancy-unemployment model showing how job quits are procyclical and how vacancy chains are created in tight labor markets. The existence of vacancy chains is also central to understanding the procyclical behavior of quits (Akerlof, Rose and Yellen 1988). Vacancy chains are shorter when unemployment is high as the probability of terminating the chain is high with so many job seekers available, who offer no job replacement. As opportunities expand, quits will increase and therefore quit behavior is procyclical.

Job flows studies of labor market dynamics stress that in imperfect labor markets flows are often an important source of adjustment (Blanchard and Diamond 1992, Burgess 1994, Schettkat 1996a). Flows reflect high levels of mobility that are not captured in measures of net change. This labor turnover or churning suggests that there are sub-surface movements that are not captured by indices of net employment change. An obvious source of this discrepancy is the existence of job chains. For the case of Germany, it has been estimated that 50 percent of employment mobility in periods of tight labor markets is due to this movement along job chains (the churning effect) and that this figure drops to less than 10 percent in periods of slack labor markets (Schettkat 1996b).

The second subject area relates to *organizational studies*. Sociologists and organizational scientists have used the vacancy chain model to study intra-organizational mobility (see Stewman 1975a, 1986). The focus of these studies is on occupational advancement and the type of organizations that promote or hinder this. Thus Stewman

(1986) uses extensive development of Markov chains in order to show that the probability of advancement within organizations is higher at intermediate levels than at lower levels. Harrison (1988) shows on the basis of U.S. data how the vacancy chain model can predict movement between different occupations nationally. Both these studies illustrate how the linear mobility model developed by White (1970) can be extended to organizational mobility applications.

One of the main uses of vacancy models in this literature has been to show remarkable similarities in the social organization of different mobility systems. Using vacancy chains to trace career paths, Stewman (1975b, 1986) has shown how similar career patterns develop in very different organizations. While much of this work is concerned with developing the mathematical and graphic frameworks for calculating the probability of advancement within the chain, the results show these mobility probabilities are relatively stable and do not decrease as much as expected as the individual moves up the career ladder. In fact mid level career positions often have greater mobility possibilities than lower levels, suggesting segmentation in intra-organizational labor markets.

The final area of application is that of *local economic development*. In this field the use of the chain model remains somewhat pedestrian. The sporadic studies that have appeared are mainly concerned with surveying and charting of chains. Two early papers looking at vacancy chains in the context of local economic development efforts relate to job shifting resulting from a program of employment creation in Alberta, Canada (Webster 1979) and a similar process resulting from expansion of coal mines in the

Hunter Valley New South Wales, Australia (Garner et.al. 1981). In both cases, extensive empirical charting leads no further than estimates of chain length.

More recently, the ‘mapping and tracking’ variant of the chain model has been revived to evaluate the impacts of urban development corporations in three United Kingdom cities (Robson, Bradford and Deas 1999) and to investigate filtering in the office and industrial property markets of North-East England (Greenhalgh, Downie, Fisher and Barke 2003) . Again, non-probabilistic (mapping) methods are employed in order to estimate chain length for commercial property vacancies and the role of the development corporations in encouraging economic regeneration in cities. These studies found particularly short local chains and use this finding to buttress the case for local targeting.

3. Chains in Action

We now review three different applications of chain-type models in urban and regional analysis. In each case non-price mobility, changes in quantity, and the existence of mark-ups are sufficient conditions to change the welfare of producers, workers and house-owners. All three cases illustrate the possibility of local economic change via alternative mechanisms to competitive price-taking. The key analytic device for observing this kind of change is the chain. The chain models developed in each instance are far from identical but together they suggest insights into the institutional structures and non-price mechanisms under-pining local and regional economies.

3.1 Production Chains and the Limits of Marshallian Welfare Analysis

As the above brief survey suggests, social science researchers have used a variety of chain approaches. In doing so, they have avoided the traditional microeconomic emphasis on the interaction of supply and demand. They have chosen chains over Marshallian welfare analysis. Why don't these research topics fit well in a Marshallian methodology? To explore this question, consider a traditional microeconomic analysis of a market with a highly elastic supply curve. Supply determines price and demand determines quantity. A small shift in demand brings forth additional supply with little or no change in price. In the traditional version of this story suppliers gain no new rents from the additional sales. However, this interpretation seems to contradict the keen interest most suppliers show in new orders at more or less fixed prices.

A long standing critique of the basic story argues that suppliers work on a markup of their average or marginal cost. The persistence of such markups can be rationalized in any number of ways. One plausible version sees each supplier as facing a firm-specific downward sloping demand curve, reflecting elements of local monopoly power derived from location, service relations, and limits on information. Despite these monopoly elements, suppliers are eager for new orders at existing prices. In this story of monopolistic competition firms work with excess supply and make real rents on additional orders. In this way, rents follow orders.

But what is true for a set of firms in industry A experiencing an increase in demand is very likely true also for their suppliers. As A-firms expand orders of intermediate goods firms in industry B, C, etc. also find themselves selling more and taking in more rents. The expansion of demand has stimulated the supplying firms to

make purchases in a broad range of intermediate goods producers. For most of these producers additional sales are likely to produce additional profits at something like a fixed mark-up or rent. Thus, even though they continue to sell at an unchanged price, supplying firms can make real gains.

These are real welfare effects. Moreover they may lead to similar expansions in other intermediate industries that in turn expand the ones in the first round. The traditional Marshallian analysis is not well suited to clarify the level or the distribution of welfare outcomes following on the initial exogenous increase in demand. A chain approach that explicitly specifies the likely series of purchases gives a much richer starting point.

In this context, in order to see what is happening we need to trace back from the demand change to the inputs feeding supply. It is the trails radiating back over these inputs and beyond that generates information about the impacts of the immediate change in demand. And for the most part, those impacts are simply proportional to quantity.

The standard tool for dealing with such production chains is the Leontief input-output table. This gives a vector of gross quantities as its output. The relation between gross quantities and net changes in final demand captures the multiplier quality of chains. A well known identity in input-output analysis expresses those gross changes (a vector Y) as a chain of rounds of required spending, stimulated by the net change (a vector X):

$$Y = X + Q * X + Q^2 * X + Q^3 * X + \dots \quad , \quad (1)$$

where Q is the requirements matrix.

Although gross outputs are often added up in this way, the value of the component activities to participants is not generally well expressed by this sum. Welfare

weights, i.e. rents derived from mark-ups, are be proportional to levels of activity, but generally will differ across industries. Thus a vector W' of welfare weights can be used to turn the vector of outputs into a scalar welfare measure (V) as in equation (2):

$$V = W' * Y = W' * X + W' * Q * X + W' * Q^2 * X + W' * Q^3 * X + \dots \quad (2)$$

where Y are the gross outputs generated by final demand shift X subject to the requirements matrix Q .

Obviously, this is not the place for a full reinterpretation of input-output analysis. Our point is to simply underscore two well known observations about this tool. First it tracks the spread of an exogenous stimulus, i.e. final demand. Second, it works best in a system of rigid or fixed prices. Let us consider each of these in turn. The material here is hardly novel, but it will help to focus our discussion of other types of chains.

The most common purpose of regional input-output analysis is to trace the spread of final demands through the region's industrial system. It starts from the proposition that demand moves through such a system in a predictable manner. The central issue is the ultimate distribution of demand across industries. The variety of the interactions among industries means that differing initial demands lead to differing distributions of intermediate demands.

A concern with the spatial spread and distribution of demand in the industrial system is not typical of traditional perfect-competition microeconomics. Material inputs of various types play little role in microeconomic theory, although in general equilibrium analysis they may be paid lip service. Traditional neo-classical theory is far more concerned with the interaction of supply and demand in determining prices and quantities in a single market. In the standard microeconomic context, a rise in demand for a

particular good is primarily of interest in terms of own price effects. Indeed, a change in quantity sold without a price change is almost a non event in such a world. For the microeconomist, “prices matter.” Indeed, it sometimes seems that prices are all that matter. In a world of efficient markets utility functions can be written indirectly in terms of prices. Similarly with respect to profit functions. Quantities fall into the background of the story and they clearly play a secondary role to prices.

But regional and urban input-output is a prime example of quantity analysis. In this world, whether for planning purposes or to gage who is likely to gain or lose from demand changes, quantities matter. In the planning context, where market mechanisms for generating substantial increases in supply may be awkward, the purpose is precisely to avoid large induced price changes by anticipating quantity needs. The assumption is that such needs can be met at more or less fixed prices if approached in a timely manner. More commonly, where the prime interest is welfare/profit gains and losses, the key starting point is that these are considerably more influenced by quantity changes than by price changes. In well developed market settings, supplies for most produced goods (as opposed to natural resources or goods heavily dependent on such resources) are highly elastic. Hence price changes are small and insignificant.

In a sense, input output analysis buys its practical power to model spread by ignoring the greater complexity of general equilibrium price adjustments in favor of greater detail on the spread of demand. An input-output model can present far more industrial detail than a computable general equilibrium model with far less data and much more manageable computational complexity.

For a wide range of impact problems quantity changes are the best guide to welfare changes. The common policy view of input output analysis most often makes just this assumption. At the local or regional scale, we do not expect sharp price changes as the result of demand changes. Where prices are relatively sticky, welfare changes for business owners come in the form of mark-ups tied to quantities. The more intermediate products purchased in the area, the greater the profits of the firms producing those products. Similarly, if the focus is on local labor markets, the more workers hired directly and indirectly as the result of the opening of a new factory, the greater the surplus received by workers. Prices or wages change occasionally, but in this world changes in quantities generally matter more. As long as weighting factors are relatively constant over time, the chain approach seems quite appropriate.

3.2 Labor Chains: Employment, Unemployment and Vacancies

Long term supply and demand decisions in labor markets have occupied a central place in applied microeconomics. The labor supply adjustments of workers to changing wage spreads--between skilled and unskilled labor, men and women, rural and urban workplaces, and many more—are the very essence of labor economics, not to mention economic history, demographics, and public policy. Similarly, the study of employers' responses to changing supply conditions—the growth of the college educated, international immigration, the expansion of the female labor force, etc.—has made real contributions to our understanding of the modern economy.

All of these applications take as their starting point a change in prices. For all of them, “prices matter.” Supplies or demand curves shift and prices change. Prices in the

market change and economic behavior responds. Information is transmitted through the price changes. Price adjustment and response is what neoclassical labor economics is all about.

There is, however, a long tradition in labor economics, deriving from institutionalist and Keynesian sources that downplays, rather than emphasizes, the role of prices in the everyday allocation of labor. In this view, wages tend to be slow to move and labor markets fail to clear on a short run basis. Involuntary unemployment at the low-skill end of the labor market is not the exception in this perspective, but rather the rule. Labor reserves and buffers grease market adjustments. When aggregate demand increases, welfare gains occur not through price adjustments, but through quantity adjustments as unemployed or underemployed workers obtain employment or underemployed workers obtain more appropriate jobs.

A simple linear treatment of the aggregate demand multiplier has long been the heart of the Keynesian textbook model. However, that basic multiplier analysis leaves undeveloped the distributional consequences predicted by the model. At best a statement can be made about changes in total GDP or total employment. The logical way to develop Keynesian distributional analysis is to more completely model the labor market using the chains approach. The chain metaphor well captures the key institutionalist and Keynesian distributional claims in the labor market. Those claims have long emphasized the great dependence of low-skilled workers relative to skilled workers on the expansion of demand.

Chain models offer an explicit, empirical framework to formalize such claims. In our own work we have emphasized the central role of involuntary unemployment /

underemployment in motivating our adoption of a chain approach. (Persky and Felsenstein, 1999) Accepting this framework, the empirical challenge is to estimate a transition matrix to use in the job chain model. Such a transition matrix should allow us to follow the likely results of an expansion in demand at any given wage level. The matrix in Table 1 is drawn from our work with the Panel Study of Income Dynamics. It shows for an average metropolitan area the likely recruiting pattern to jobs in five different wage categories, from highest in column 1, to lowest in column 5. Each column shows the proportion of vacancies at that level taken by job-changers characterized by the wages on their former job (rows 1-5). Of course no vacancy generates an endless chain. Rather, real chains are ended by a terminating event. Thus in the matrix we include the probability that a vacancy in a given column will end in the hiring of an unemployed worker (row 6), a worker not in the labor force (row 7), and a working in-migrating to the area (row 8). These last three categories of job takers leave no corresponding vacancy for others to fill.

Once estimated, such a matrix can be used to trace the impact of new vacancies in the average metropolitan area. To start with, it is a relatively easy matter then to estimate the expected length of chains (see Persky, Felsenstein and Carlson, 2004.)

Table 1: A Job Chains Matrix

	New Wage Group				
Origin	1	2	3	4	5
Wage Group 1	q ₁₁ =41.1%	0.0%	0.0%	0.0%	0.0%
Wage Group 2	q ₂₁ =25.0%	q ₂₂ =52.9%	0.0%	0.0%	0.0%
Wage Group 3	q ₃₁ =4.8%	q ₃₂ =22.1%	q ₃₃ =46.6%	0.0%	0.0%
Wage Group 4	q ₄₁ =2.2%	q ₄₂ =1.5%	q ₄₃ =18.5%	q ₄₄ =47.3%	0.0%
Wage Group 5	q ₅₁ =0.0%	q ₅₂ =0.3%	q ₅₃ =2.4%	q ₅₄ =13.3%	q ₅₅ =34.5%
Unemployed	t ₁₁ =2.9%	t ₁₂ =3.8%	t ₁₃ =9.7%	t ₁₄ =15.8%	t ₁₅ =24.7%
Not-in-Labor Force	t ₂₁ =4.0%	t ₂₂ =3.8%	t ₂₃ =7.5%	t ₂₄ =13.5%	t ₂₅ =30.5%
In-Migrant	t ₃₁ =20.1%	t ₃₂ =15.6%	t ₃₃ =15.4%	t ₃₄ =10.0%	t ₃₅ =10.2%
Column Sum	100%	100%	100%	100%	100%

Given this type of chains matrix, a Leontief inversion of the square top portion of the matrix can be used to estimate the length of typical vacancy chains. More importantly, this matrix can also act as the basis of a distributional analysis if we simply keep track of the expected numbers of workers moving between various categories. Assuming wages remain rigid at each level, these transitions can be weighted by change in workers earnings to provide an expected distribution of welfare gains by groups.

More generally the welfare gain v per job created at level j can be estimated as

$$v_j = \sum_i m_{ij} (w_i) [(\sum_k q_{ki} g_{ki} + t_{ui} (1 - oc_{ui}) + t_{ni} (1 - oc_{ni}) + t_{mi} (1 - oc_{mi}))], \quad (3)$$

where m_{ij} is the Leontief multiplier derived from a job chain matrix like that in Table 1, w_i is the wage for a job at level i , q_{ki} is the entry on the k th row and i th column of the job chain matrix, g_{ki} refers to the percentage wage gain in moving from job type k to job type

i , and oc stands for opportunity cost, with u , n , and m subscripts representing unemployed, out of the labor force and in-migrant.³

Equations like (3) allow the estimation of the efficiency benefits associated with job creation, defined here as the ratio of welfare gains to new wages. Depending on the magnitude and character of the stimulus, a chain analysis of this type can provide considerable information about the economic value of job creation. In doing so it offers a consistent extension of the Keynesian story in a world of involuntary unemployment/underemployment, rigid wages and institutionally determined recruiting patterns. Moreover, it is a fairly easy matter to disaggregate such expressions to obtain estimates of the distributional consequences of job creation, i.e. the share of welfare gains to workers at the low end of the wage distribution. The constructive nature of chain analysis makes such disaggregation straightforward.

The chain approach to evaluating job creation gives robust welfare estimates as long as the basic institutional structures supporting a chain remain stable. At some point, of course, such structures may break down. For example, a large increase in labor demand might result in sizable changes in wages and a range of substitutions, events better discussed in Marshallian terms. Hopefully, empirical research on the stickiness of wages will eventually allow us to identify such breaking points.

³ Perhaps the most difficult parameters to estimate in (3) are the opportunity costs (oc_j 's) of the various terminal states in each column. In our own work we try to link these opportunity costs to the expected unemployment rates for each type of worker.

3.3. Housing Chains and Residential Filter Down

Rapid urban growth in the United States in the early 20th century gave rise to housing markets in which demand tended to outrun supply. Early observers such as Hoyt (1939) emphasized the role of new construction in opening vacancy chains. While the Great Depression undermined real estate markets of all types, World War II again restored the short-side power of suppliers. At the end of the War, with U.S. housing in particularly short supply, the appeal of vacancy-chain-methodologies became strong. In the late 1940s newly built homes set off very real chains of vacancies as families sought housing opportunities. A short chain might mean a new dwelling was occupied by an in-mover to a region or a newly formed household. A long chain might retell the moves of a number of households each improving its housing quality. The end of such a chain might reach down to those of modest income and wealth, even though the start began in the upper regions of the income distribution.

Housing chains are easier to study than job chains or production chains. From the vantage point of practical data acquisition housing chains have a great advantage. Researchers can reconstruct actual chains in a straightforward manner by simply tracing new home purchasers to their starting address and then determining the new household taking over that residence. Unlike jobs, structures have a clear identity independent of their inhabitants. Where it is often unclear who replaced whom in an actual job chain, for housing chains such determinations present only modest difficulty. Under the circumstances actual chains can be estimated and statistics based on real observations rather than probabilistic constructs as in the job case. Nevertheless, much housing chain work is conducted in the same probabilistic mode as job chains (Chase, 1991).

For example Table 2 presents a housing chain matrix based on the work of Marullo (1985) and discussed by Chase (1991).⁴ Such a matrix can then be used to calculate the expected length of housing chains starting with each housing quality. Notice in this case the short-side of the market is presumably the supply side, so that vacancies move spontaneously down a chain.⁵ This matrix can then be used to calculate a vacancy multiplier for every type of newly constructed home.

Table 2: A Housing Chains Matrix*

Old Home	New Home		
	High Quality	Mid Quality	Low Quality
High Quality	0.45	0.08	0.01
Mid Quality	0.38	0.39	0.09
Low Quality	0.09	0.35	0.38
Outside**	0.08	0.19	0.52

*Table based on Marullo (1985) as discussed by Chase (1991).

** Outside includes all terminating states for a housing chain: in-migrant, destruction of previous house, moves from apartments, new household.

⁴ Like most of the housing literature Marullo views chains as the result of Markov vacancy moves. Thus a transition event involves a vacancy moving from an origin state to a destination state. In Table 2 we have recast these moves such that a transition event moves a household from an origin state to a destination state. The origin of a household is the destination of a vacancy and visa versa. Given the formal similarity to our Leontief labor chains, we will refer to these as Leontief chains.

⁵ The usual assumption in the housing chains literature is one of excess demand and in the labor chain literature one of excess supply of labor. Emmi and Magnusson (1994) would call both of these Markov supply of vacancies models.

While the housing literature has not formalized efficiency and distribution measures in the labor literature, the analysis of distributional outcomes has had a primary place in housing chain studies. A key distributional proposition--that chains starting with high quality new housing generate considerable welfare gains for modest income households--became the central claim of the filtering school of housing policy. As such it was embedded into a range of public programs in the U.S. and elsewhere. And yet, over the years housing analysts have become largely disillusioned with the simple filtering story. In the process, the usefulness of housing vacancy chain modeling has also been called into question.

Empirical work on chains has raised severe doubts about the simple filtering story. Lansing, Clifton and Morgan (1969) found chains initiated by new construction often disrupted by immigration, new household formation or demolition. As such they generated few gains for low income families. Similarly, Forrest and Murie (1994) found much churning, but little inter-class filtering.

In and of themselves such observations do not demonstrate that chain modeling is inappropriate for housing studies. Because the chain does not go exactly where one hoped or expected is not a refutation of the approach.

However, housing chain models have more serious problems than just their failure to give the hoped for filtering result. In contrast to the other markets discussed in this paper, housing markets tend to be volatile in terms of price.⁶ With the supply side inelastic over the short and intermediate run, prices can vary considerably with demand

⁶ We focus here on markets for owner occupied residences. Apartments tend to show considerable price stickiness (Genesove, 2003).

changes. Substantial price changes lead to major welfare changes for various income and demographic groups. The distribution of welfare can be substantially effected by marginal changes. Rather than welfare effects being restricted to long, well defined quantity chains, they are likely to spread through price changes to wide groups.

From the start, the housing filtering model was couched in terms of price adjustments as well as quantity changes. The analytical machinery necessary to follow such changes requires a full articulation of supply and demand elasticities through a range of quality levels.⁷ Thus changing local circumstances on the demand side are likely to produce very different results depending on broader market circumstances. Where we find a high degree of stability in labor chains over the business cycle (Persky, Felsenstein, and Carlson, 2004), the cyclical nature of housing markets points toward considerable variation in the character of housing chains. Thus Forrest and Murie (1994) find sharply different housing chains in the booming southern English housing market of the 1980s and the same market in the recession of the early 1990s.

Such rapid changes in chain structures are matched by rapid changes in welfare consequences. The demographics of households involved in chains differ across the cycle. Hence the direct and indirect welfare effects must differ. Moreover, changes in markets are spread to households not involved in the chain of transactions as housing price changes affect asset positions.

Housing chains computed at a given time and place can be used to construct multipliers and may provide useful institutional insights into the workings of the housing

⁷ See for example the essentially Marshallian treatment of filtering presented by McDonald (1997) pp. 216-221.

market. However, they cannot form a solid foundation for the type of welfare analysis identified in this paper. As such they play a much more limited role than chain analyses in labor markets.

4. Conclusions

Table 3 summarizes the attributes of the three types of chains (production, labor,

Table 3: Chains by Attributes

Attributes	G-Chain (Leontieff – Production)	L-Chain (Labor market)	H-Chain (Housing)
Direction of Movement through chain	Goods – physical transformation (horizontal)	Workers – moving up Vacancies reaching down	Housing declining Households improving
Driver of Movement	Technology	Job Opportunities	Housing Opportunities
Stickiness in Movement through Chains	Low	High	Moderate
Role of Prices	Fixed	Fixed	Variable
Welfare Gains via	Quantity Change	Job Change	Quality Change <i>and</i> Asset Prices
Characteristic of Market	Highly Elastic Short Run Supply	Highly Elastic Short Run Supply	Inelastic Supply in the Short Run

and housing) discussed above. All of these chains in principle allow the sequential recording of linked transactions. However, as seen in Table 3, these chains appear quite different in several crucial respects. In particular, we see that housing chains embedded in active markets with considerable price variation present a set of attributes somewhat at odds with the other two market groups considered.

When do chains provide more than a transactions accounting database? Or put somewhat differently, when is a serial transactions accounting database the beginning of a model? From the above we find that housing chains provide the least complete description of the markets in question. Because housing prices change and housing prices matter, welfare effects of transactions are not limited to participants in those transactions. While housing chains exist, they hardly tell the whole story. The institutional mechanisms are not as rigid; prices tend to clear markets, and allocation is strongly influenced by prices. Welfare effects also follow from price changes.

For labor chains and production multipliers, prices are much stickier. As a result the major welfare consequences of transactions are largely limited to participants in those transactions. Institutional characteristics play a much larger role than active price adjustments in allocating scarce demand. While there may be modest roles for non-price competition (quality of goods, delivery times, labor skills etc.) these are much more limited in their effects on non-participants than more traditional price competition.

In the presence of well working markets with active price competition, demand equals supply and market matching generates no meaningful chain. It is the combination of mark-up pricing and mobility-driven rents that makes chains interesting. Clearly under these circumstances the significant research task is to more fully identify the

institutional allocation mechanisms that lie behind the chains. For example, labor chains are influenced by non-price factors such as personnel policies, union contracts, public referral services and a range of other institutional structures.

Over time most real world markets evince aspects of broad price-competition *and* narrower chain allocation. Recent research fashions have tended to emphasize the former, largely ignoring the institutional basis of the latter. Hopefully, a clearer statement of the usefulness of the chain approach can help to renew interest in the institutional allocation structures that characterize so much of the economy. Multipliers, mark-ups and mobility rents are often interconnected in ways best developed in a chain approach. While housing markets may prove a poor choice for chain analogies, production and labor markets often evince just that combination of characteristics well described by chain mechanics. Input-output has been a basic tool of regional analysis and is well respected for its description of multiplier processes. Labor chains add another dimension to the multiplier concept in a defensible context, one in which price changes play only a secondary role.

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