AN ECONOMETRIC MODEL OF THE ISRAELI HOUSING MARKET

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1. Introduction

In this paper we report our efforts to estimate an econometric model of the Israeli housing market estimated from quarterly data over the period 1974-90. The principle endogenous variables in the model are housing starts and completions, the stock of housing, house prices and rents. The specification of the model draws on capital asset pricing theory in which account is taken of stock-flow phenomena that are inherent in the housing market. At a given point in time the stock of housing is fixed and house prices are treated as the price of a capital asset which clears the asset demand for housing. At the same time house-building is motivated by profitability which reflects the level of house prices. Increased building activity raises the stock of housing over time which, in turn, feeds back on to house prices.

Models of this type originate in the theoretical work of Witte (1963) and have been adopted in textbooks, see e.g. Dornbusch and Fischer (1990) in their discussion of housing investment. Perhaps the earliest, and in many respects, the most ambitious attempt to estimate econometric models of this type from time series data are the efforts of Smith (1969) for the Canadian housing market. His model includes the determination of housing starts, house prices, the price of land, construction costs and the mortgage market. Keal (1979) too reports a comprehensive model for the US housing market although due to absence of the necessary data he abstracts from land prices. He showed that because mortgages are not index-linked inflation raises housing demand, thereby raising house prices which in turn stimulate new-building. More recently, DiPasquale and Wheaton (1994) have suggested that the absence of data on land prices may be captured by specifying the lagged housing stock in the equation for housing starts. They also suggest that there is a considerable degree of inertia in house prices that is consistent with adaptive rather than rational expectations in the US housing market.

There have been several attempts to estimate economic models of local as opposed to national housing markets in terms of the basic stock-flow theory that has been mentioned, e.g. Davies (1971) for London Ontario and Engle, Fisher, Harris and Rothenberg (1972) for Boston. Indeed, the latter model, while incomplete, is ambitious in that it attempts to model migration into and out of Boston.

The copious literature on the econometric modelling of housing markets has been complemented by an ancillary literature which has addressed specific issues such as the specification of housing starts by Topel and Rosen (1988), the relationship between starts and completions by Lee (1992), the determination of house prices by Hendry (1984) and Ericcson & Hendry (1985) in the UK and Mankiw and Weil (1989) and Poterba (1991) in the US, and the effects of tax distortions on the housing market in Poterba (1984).

The efforts that we report below for the Israeli housing market both complement and parallel the extant literature in several respects. First, as a country which has experienced, and continues to experience, large and often protracted demographic shocks Israel makes an ideal case study for estimating the effects of demography on the housing market. During the 1990s the population has risen by more than 20 percent due to the arrival of immigrants from the CIS, real house prices have soared by 70 percent and house-building has increased by 50 percent. Secondly, the extant literature tends to assume the existence of a competitive, if tax-distorted capital market. By contrast, the Israeli capital market is relatively imperfect. Therefore, Israel presents an opportunity to study the behaviour of housing markets when housing finance for both prospective buyers and contractors is not competitively determined. Thirdly, and relatedly, the government has traditionally acted as a key player in the housing market. It has subsidized housing construction and it has provided eligible groups with subsidized mortgages. It has also monopolized the supply of new building land. Therefore, Israel serves as a testing ground for investigating the effects of government intervention on the housing market. In short, because of the peculiar (though not unique) institutional character of Israel's housing market we may investigate phenomena that are less easily observed elsewhere. On the other hand, because mortgage interest payments are not subject to tax relief, and because there are no capital gains taxes, the tax distortion issue that has been the focus of much interest in the US, Poterba (1984), is not relevant to Israel.

Finally, a novelty of the model that we propose is the articulation of the nexus between housing starts and completions. This nexus if often left vague in standard models;[1] typically there is an equation for starts but no explicit account is taken of the gestation lag in building. Inevitably, the specification of the starts-completions nexus affects the dynamic character of the model.

The paper is organized as follows. In the next section we introduce the data and salient institutional features of the Israeli housing market. This is followed in section 3 by a discussion of the theoretical structure of the model to be estimated. The model itself is described in section 4. Simulation properties are presented in section 5. Finally, in section 6 we review outside sample developments during 1991-1994 in the light of the model. The end of the observation period coincided with the onset of a major wave of immigration from the ex-USSR which swelled the population by some 15 percent during the first four years of the 1990s. Not surprisingly this demographic shock has dominated the housing market, and indeed the economy as a whole, during the 1990s. To have included the 1990s in the sample period may have jeopardized the estimation since these

[1] An exception is the work of Dicks (1990) on the UK housing market.

observations were inherently atypical. Nevertheless, it turns out that with certain adjustments the post sample performance of the model is satisfactory.

2. Institutions and Data

As a young country, Israel has experienced unusually rapid population growth on account of immigration. Since achieving statehood in 1948 almost half of the increase in population has been due to immigration with the balance due to natural increase. During the 1950s many immigrants had to spend several years under canvas in transit camps before proper housing became available. During the 1950s and 1960s housing construction was undertaken directly by government bodies. By the mid 1970s, however, private contractors had become predominant and the government limited its involvement to initiating construction by ordering housing from private contractors instead of building them directly. Usually the government accompanies its orders with financial incentives so that private contractors will have an incentive to respond. On completion the government sells the houses in the housing market.

The Israel Land Administration (a government agency) owns over 90 percent of the land in Israel. It leases building land to the private sector for 49 years. None of the leases has yet expired because the country was established less than 49 years ago. However, it is widely expected that the leaseholds will be automatically rolled over at no cost. To engage in new building contractors must first obtain land from the ILA or from the relatively small number of private freeholders. The price of new building land depends inter alia on the rate at which the ILA releases its land reserves. The effective supply of building land also depends on the intensity of building per square meter; high-rise developments enhance the effective supply. Unfortunately, the ILA does not publish systematic data on land prices nor are data available on building density.[2]

The vast majority (75 percent) of Israeli housing is owner-occupied. There is a small public housing sector in which housing is rented at subsidized rates, especially in peripheral areas. In 1989 this sector accounted for approximately eight percent of all households. Another seventeen percent is accounted for by other private rented accommodation.

Until 1955 private rents were controlled, however, they have been subsequently deregulated and left to market forces. Properties that were first rented prior to 1955 continue to be controlled. However, a system of key-money has developed and was subsequently legalized so that when the tenancies change hands the key-money can be adjusted to reflect market forces. As a result of the rapid growth of residential building since 1955 the rent-controlled sector is now very small (less than ten percent of the rented sector).

While the last decade has witnessed significant improvements, the capital market in Israel remains imperfect, segmented and administered. In the case of housing there is no well-developed mortgage market, although matters have improved considerably in the last few years. The government provides restricted mortgages to young couples and immigrants at subsidized interest rates. Until 1979, mortgage payments were not indexed so that the acceleration of inflation greatly reduced the cost of these mortgages and real mortgage rates were often negative until indexation was introduced.[3] The absence of a well-

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[2] But see the efforts of Pines and Perlman (1993) who infer the price of land from data on house prices.

[3] However, since 1992 these mortgages are only partially indexed in which case the rate of subsidy once more varies directly with inflation. For a detailed discussion of mortgage subsidies see Bar-Nathan (1988).

developed mortgage market implies that housing is largely financed out of own resources. However, parents help their children to an unusually large degree in financing home-buying.

Unless otherwise stated the central housing variables[4] are published monthly by the Ministry of Housing and Construction in Meyda Hodshi which is only available in Hebrew. The house price index is hedonic[5] and is prepared by the Central Bureau of Statistics (CBS). Real house prices (deflated by the CPI) have tended to rise over time, but especially in the 1960s and the 1990s. In common with many other countries, Poterba (1991), Israeli house prices are volatile in both directions (see Figure 1). By contrast real building costs (excluding land prices) have trended downwards and are less volatile (see Figure 3 and Figure 2 for housing starts). Real rents[6] fell by 50 percent between 1974 and 1980 but recovered their erstwhile level by 1990, whence they have risen with the wave of immigration (see Figure 8).

It should be noted that an unusually large proportion of the labor force in the construction sector comes from the West Bank and Gaza. In 1988 this proportion was approximately forty percent. The building technology is labor-intensive because labor is

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[4] These variables include starts (by unit and area), completions (unit and area), house prices, rents, building costs, demolitions, redesignations (commercial-private housing), and advance sales. A diskette of all the data may be requested from the Ministry of Housing and Construction. The majority of the data are monthly but see footnote 5.

[5] The hedonic factors include number of rooms, size and location. The underlying data come from transactions upon which stamp duty has been paid. Since 1983 the original data are quarterly. Before 1983 the data were published quarterly but referred to the previous six months. We solved for the implied quarterly data from the underlying first order moving average model for the overlapping data.

[6] Adjusted for size, etc. Given the marginal nature of the rental market, the housing covered by the house price index and the housing covered by the rental index may not be strictly comparable.

relatively cheap. Indeed, as shown by Bar-Nathan (1986), total factor productivity (not, however, adjusted for the quality of labor) in construction grew slowly and even declined in certain subperiods as cheap labor from the West Bank and Gaza replaced more expensive Israeli labor in the aftermath of the 1967 Six Day War. Since the outbreak of the Intifada in November 1987 the supply of labor from the West Bank and Gaza has been disrupted from time to time. Since February 1993 work permits have been restricted for reasons of security and the share of Israeli labor and foreign workers has risen.

As previously noted, the government is a key player in the housing market. In the early 1970s the public sector accounted for roughly half of total housing construction. However, this fell to slightly more than 10 percent by the mid-1970s. The public sector share rose to 60 percent by 1980 before falling once more by the mid-1980s. During the 1990s public sector involvement has increased once more following the upsurge in immigration of Soviet Jewry in late 1989 (see Figure 4).

We have already noted that the Israeli capital market is far from perfect. This is not only true for home-buyers it is also true for building contractors who face difficulty in raising capital. This induces contractors to sell housing at a discount before it is completed (and quite often even before it is started). This eases their cash flow and enables them to initiate new projects. Between 15-40 percent of new houses are sold by the time the basic structure has been built (see Figure 5). In our model this variable serves as an indicator of advanced selling.

There are no published time-series for the housing stock in Israel either in terms of units or by area. Census data for 1961, 1972 and 1983 provide snap shot data of the housing stock. Using these data together with data on completions and assumptions about demolitions and redesignations (for which systematic data were not available until recently) we may attempt to construct a series for the housing stock. Under plausible assumptions regarding demolitions and redesignations it turns out that the derived housing stock series matches the census data.[7] The housing stock per adult has risen from 35 square meters in the early 1970s to 45 square meters by the late 1980s. In the meanwhile the size of housing units rose from an average of about 76 square meters in 1975 to about 90 square meters in 1990 (see Figures 6 and 7). We therefore calculate the housing stock series both in terms of units and area. Clearly the relevant variable to model is house building by area rather than units and the stream of housing services depends on the area of the housing stock rather than the number of units. In a number of models e.g. DiPasquale and Wheaton (1994), it is the number of units that is modelled.

3. Theoretical Structure

3.1. Conception

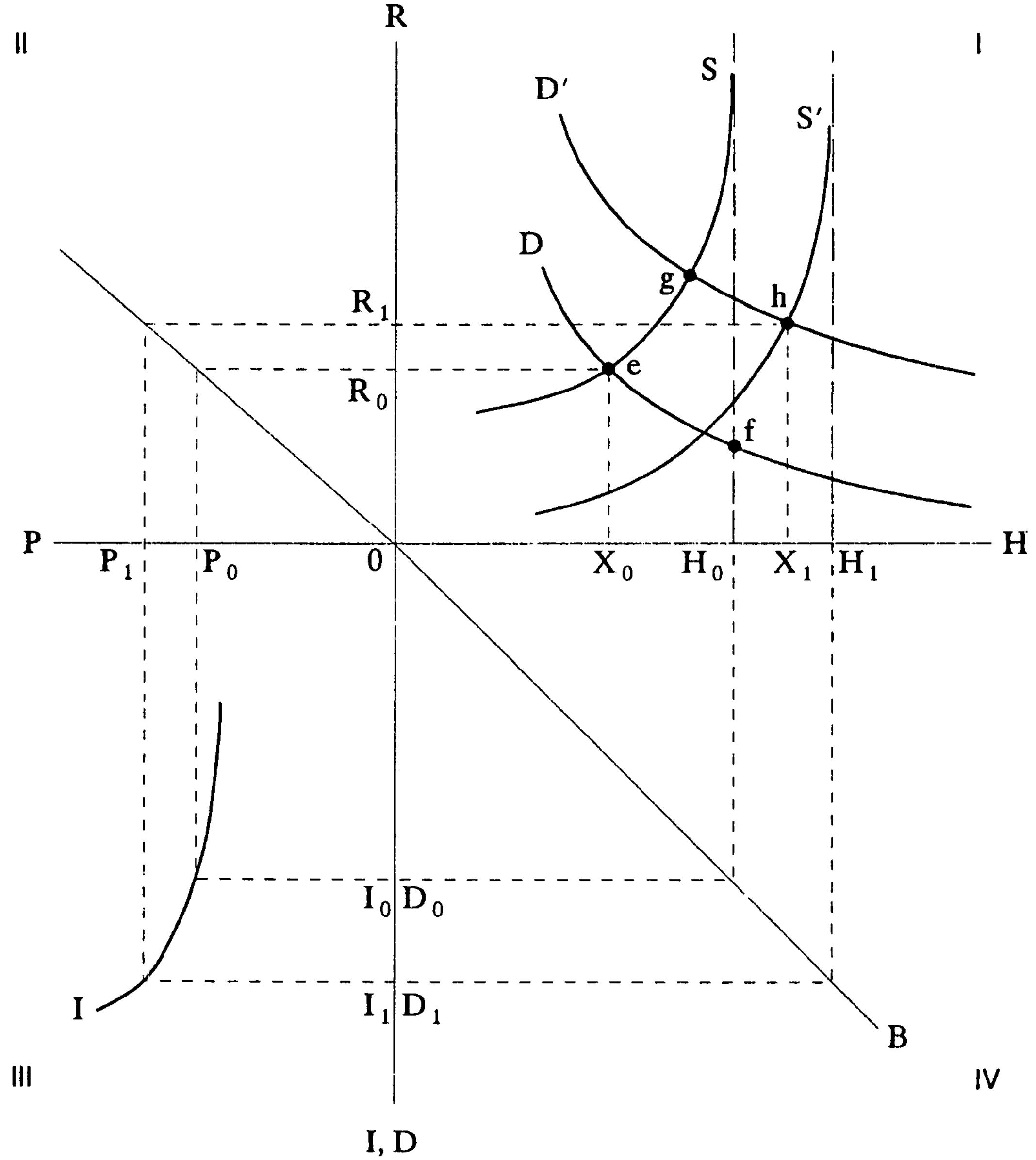
In a perfect housing market where agents have perfect foresight households would be indifferent between owner-occupation and renting in which case the unit rental rate (R) would be equal to the user-cost of housing minus the real rate of capital gains on housing, i.e

$$R = P(\tau + \delta) - \Delta P/P_{-1} \qquad (1)$$

where P denotes the unit price of housing, τ the rate of interest and δ the rate of depreciation. In fig. 1a the relationship between rents and house prices that is implied by equation (1) is represented in panel II. It is drawn under the assumption of zero capital

[7] Another census is scheduled for 1995. This will enable us to determine whether our series matches the new census data. Redesignation occurs when appartments are used for commercial purposes and vice-versa.

Figure 1a. The Housing Market in Equilibrium



Filename: HOU-MART.WPG

gains. If the rate of interest rises OA rotates in a clockwise direction.

Panel I represents the market for housing services. The demand schedule for housing services is assumed to vary inversely with the relative price of housing services and directly with shift variables such as income (Y) and population (POP):-

$$D = D(\overset{-}{R},\overset{+}{Y},\overset{+}{POP}) \tag{2}$$

In equation (2), as elsewhere, the signs of partial derivatives are indicated over the variables to which they refer.

At a given point in time the housing stock is predetermined and is assumed to be H_0. Since the demand schedule in panel I measures the demand for housing services H, it is defined in terms of area (square meters) and the service stream is assumed to be proportional to the stock of housing. The supply schedule (S) in panel I is drawn asymptotically to H_0. As rents rise, house-owners are more prepared to rent out their properties but there is a natural, upper limit, H_0. The upward sloping S schedule either implies that renting is risky (contracts may be broken, the tenant may damage the property, etc.) or landlords face different costs of renting in which case some landlords may not wish to let if rents are not sufficiently high. The rental rate that clears the market for housing services is R_0, the equilibrium capacity utilization rate is X_0/H_0 and the "natural vacancy rate" (Rosen & Smith (1983)) is H_0X_0/H_0. In the absence of risk or rental costs, the equilibrium would be at f rather than e, rents would be lower, capacity utilization would be 100 percent[8], and the "natural vacancy rate" zero.

The supply schedule may be represented as:-

[8] Letting risk would imply that equation (1) should be written as $XR/H = P(\tau+\delta)$ but this is ignored in fig 10.

$$S = S(\overset{+}{R},\overset{+}{H}) \qquad (3)$$

Equations (1),(2) and (3) together with the equilibrium condition S=D imply the following reduced-form in house prices:-

$$P = P(\overset{+}{Y},\overset{+}{POP},\overset{-}{H},\overset{-}{\tau},\overset{-}{\delta}) \qquad (4)$$

In equation (4) the partial derivative P_H varies inversely with the elasticity of the supply schedule (S) and with the elasticity of the demand schedule (D) in panel I.

Panel III plots the marginal cost schedule of building on the assumption that new and secondhand prices are perfectly correlated. Thus building investment (I) varies directly with the price at which contractors can sell their product. Here we assume that there is no gestation lag in building (but see section 3.2 where this issue is discussed). The location of schedule I depends on unit building costs which comprise labor and raw materials (C) and the cost of land (P_n). Hence:

$$I = I(\overset{+}{P},\overset{-}{C},\overset{-}{P}_{n}) \qquad (5)$$

If, for example, the supply of new building land is completely inelastic the I schedule in panel III would be horizontal at I_0 in which case all building is replacement investment. However, the price of land varies directly with demand and inversely with supply. The latter reflects sales of building land by the ILA and changes in building density as determined by the local authorities. DiPasquale and Wheaton (1994) have suggested that P_n may be proxied by H, for the greater is H the smaller will be remaining reserves of land. This implies that the partial derivative of I with respect to H is negative. If, however, ILA stabilizes land prices by making sufficiently new building land available, I will be independent of H.

Finally, the schedule OB in panel IV represents the steady-state ratio of demolitions to the housing stock. When the housing stock is H_0 a proportion D_o of them are demolished in each period. The demolition rate depends upon the quality of the structures - cheap building would tend to steepen the OB schedule.

Fig 1 depicts the housing market in steady-state equilibrium, i.e demolitions equal housing investment ($I_0 = D_0$) such that the stock of housing remains unchanged at H_0 while rents and house prices remain respectively at R_0 and P_0. If, for example the demand for housing were to rise from D to D‘ in panel I, house prices and rents would jump to g. Investment would increase until a new steady-state was achieved at h with housing stock H_1 and capacity utilization $X_1/H_1 > X_0/H_0$ - because rents are greater at their new equilibrium R_1. House prices must be higher at P_1 because replacement investment is necessarily greater at I_1. The speed at which the new steady-state is reached varies directly with the elasticity of the investment schedule in panel III. Until this new steady-state is reached R, I and P overshoot R_1, I_1 and P_1.

3.2 Building Gestation

In section 3.1 it was assumed that building was instantaneous, the gestation lag was zero. In practice the contractor must decide whether to build more quickly in which case he sells the house sooner and saves interest on his capital invested in the project, or to delay in which case his construction costs will be lower. Here we assume that building costs vary inversely with building gestation (T) i.e.

$$Z = Z(T)$$

where Z is the total outlay on labor and raw materials and $Z'(T)<0$. These costs are assumed for simplicity to be disbursed in a uniform fashion during the course of the project so that the outlay in time period t is:-

$$X(t) = Z(T)/T$$

The present value from the project is therefore:-

$$PV = Pe^{-\tau T} - \frac{Z(T)}{T}\int_0^T e^{-\tau t}dt$$

where τ is the cost of capital to the contractor which, if the capital market is imperfect, may differ from the market rate of interest. The objective is to maximize PV with respect to T. The first order conditions imply that the optimal building gestation is the solution to:-

$$-\tau Pe^{-\tau T} - \left(\frac{Z'}{T} - \frac{Z}{T^2}\right)\left(\frac{1-e^{\tau T}}{\tau}\right) - \frac{Z}{T}e^{-\tau T} = 0 \qquad (6)$$

If, e.g. we assume for simplicity that $Z=k/T$ equation (6) becomes:-

$$\frac{\tau^2 PT^3}{2k} + \frac{\tau T}{2} + 1 = e^{\tau T}$$

in which case the solution for the optimal gestation period is approximately equal to:-

$$T = \frac{k}{P}(1 + (1 + P4/\tau k)^{1/2})/2 \qquad (6a)$$

the first three terms of the expansion $e^a = \sum_{i=0}^{\infty} \frac{a^i}{i!}$. The table presents some numerical illustrations for T when P is normalized at unity.

Case	τ(p.a.)	k	T(years)

1	0.05	0.1	1.465
2	0.05	0.08	1.305
3	0.06	0.08	1.195

Case 1 indicates that when the interest rate paid by contractors is 5 percent per year and total building costs are a tenth of house prices (k=0.1) the optimal gestation lag is 1.465 years under the assumptions of the model. Case 2 shows that if building costs fall to 8 percent of house prices the gestation lag falls to 1.305 years; it pays to complete quicker because building requires less circulating capital. If the contractor's rate of interest rises (case 3) it pays to build quicker because in this way the contractor minimizes interest payments. In summary, equation (6) implies that the gestation lag varies inversely with the rate of interest and house prices and it varies directly with building costs.

3.3 Advanced Selling

In section 3.2 the contractor was assumed to sell on completion. However, in an imperfect capital market he may prefer to sell prior to completion. We denote $\mathcal{T} \in (0,T)$ as the selling time and we assume that the sooner he sells the less he receives from the buyer, i.e. $P=P(\mathcal{T})$ where $P'>0$ and $P(T)=P$. For a given rate of interest that the contractor pays the optimal time to sell may be determined by minimizing $P=P(\mathcal{T})e^{-\tau\mathcal{T}}$ with respect to $\mathcal{T}$. The first order condition implies that $P'/P = \tau$. If $P''<0$ this implies that the greater the rate of interest paid by the contractor, the sooner it pays him to sell.

This is likely to occur when the contractor wishes to finance new building; his attempt to raise the necessary capital increases the rate of interest and he is induced thereby to sell in advance at a discount. Under the circumstances he may also be motivated to complete more rapidly because his shadow cost of capital has increased. If, on the other hand, house buyers happen to be liquid the schedule $P'(\hat{T})/P(\hat{T})$ will "shift to the right" so that the contractor will prefer to sell later and at a better price.

3.4 Rents

There are several compromises between the estimated version of the model and the conception as presented in section 3.1. In an imperfect housing market renting and owning will not be perfect substitutes in which case equation (1) will not apply. Owning provides security of tenure whereas renting does not. Once the rental contract is over the tenant has no guaranteed right to remain. Nor does renting provide security to the landlord - rent is not equivalent to the return on a riskless capital asset. Indeed Ioannides and Rosenthal (1994) and Blackley and Follain (1991) demonstrate empirically that in the US renting and owning are imperfect substitutes. The former claim that the consumption demand for housing is less sensitive to wealth and income than the portfolio demand for housing. Hence, the rich have a penchant to own relative to the poor. This would imply that as societies become richer rents fall relative to house prices.

In inflation prone societies such as Israel, the propensity to own rather than rent may be affected by the rate of inflation. We suggest two considerations. Insofar as owning provides a hedge against inflation rents are likely to fall relative to house prices as inflation increases. On the other hand, when inflation is very high (say, in excess of 100 percent per annum) the riskiness of owning increases, since in the absence of perfect wage indexation real incomes become more volatile. On the other hand, mortgage payments are perfectly index-linked. This effect implies that at high rates of inflation rents may rise relative to house prices.

These and related considerations induce us to modify equation (1) to:-

$$R = R(\overset{+}{P}, \overset{-}{\Delta P}, \overset{+}{\tau}, \overset{?}{Y}, \overset{?}{INF}) \tag{1a}$$

where according to Ionnides and Rosenthal (1994) $R'_Y<0$ and where INF denotes the rate of inflation. $R'_{\Delta P}$ is expected to be negative since landlords accept lower rents when house prices are expected to appreciated in value.

In the light of these considerations we estimate equation (1a) without imposing the restrictions implied by equation (1). Indeed, these restrictions clearly do not apply in the short run. However, we argue that the proportionality between rents and house prices in equation (1) applies in the long run (see Meese and Wallace (1994)) and that the rental sector is recursive to the main body of the housing market, i.e. the owner-occupation sector.

A further compromise between the estimated model and the conception concerns imperfections in the capital market. During the last few years the market in private sector mortgages has developed as an integral part of the liberalization of the Israeli capital market. However, during the bulk of the estimation period the long term capital market was dominated by the government and it was difficult for private borrowers to access long term credit. This meant that the demand for housing was liquidity constrained and that borrowers had to look to the commercial banks for limited short-term credit. These considerations suggest that the demand for housing is likely to reflect the wealth held by the household sector rather than interest rates, especially long-term interest rates. Indeed, it is most probably for this reason that the effect of interest rates on the demand for housing turns out to be empirically weak.

Finally, it should be noted that inflation was high during most of the observation period. Inflation began to rise in the early 1970s, by 1980 it exceeded 100 percent per year and peaked at about 500 percent in 1984/5. Subsequently, it has fallen to between 15-20 percent per year. Despite the widespread practice of indexation both in labor and capital markets, inflation considerably distorted the economy as a whole including the housing market.

Until 1979 subsidized mortgages were not index-linked in which can inflation increased the value of subsidy, thereby raising the demand for housing. Rental contracts have been more or less index-linked because they are indexed to the shekel: dollar exchange rate. Nevertheless, as we argue below, it is difficult to understand the empirical relationship between rents and house prices in Israel without taking account of the effects of inflation on the demand for house ownership.

3.5 The Public Sector

As noted in section 2, the public sector plays a key role in housing construction by initiating house-building with private contractors. There is no reason why in itself public sector building should raise total building activity. If all that goes on is intermediation by the public sector, public sector starts should "crowd out" private sector starts one-for-one so that total starts do not change. Instead of the order to build originating in the private sector it originates in the public sector. Once the house is built it is sold to owner-occupiers at a price which would have prevailed in any event. In these circumstances the effect of the public sector is neutral; it simply disintermediates.

In practice, however, there is more than mere disintermediation that takes place. A public sector start is usually accompanied by various financial incentives, e.g. favourable lines of credit, discounts on land prices and site development costs, etc. This has the effect of subsidizing house construction as a whole. On the other hand, building for the public sector may incur extra expense on account of dealing with the bureaucracy. In the absence of data on the net rate of subsidy itself we assume that it varies directly (but not necessarily linearly) with the share of the public sector in total starts.

4. Econometric Estimation of the Model

The equations of the model are listed in table 1. For the most part they were estimated in the form of "error correction models" in which the dynamic specification of the equations was guided by the general-to-specific methodology of dynamic estimation. We experimented with lags of up to four quarters, hence we have allowed for fairly complex dynamic structures. Given the widespread presence of lagged endogenous variables we use the lagrange multiplier statistic (LM) to test for up to fourth order serial correlation in the equation residuals. It has a χ^2 distribution with 4 degrees of freedom. We also test for structural stability of the equations over the period 1989Q1-1990Q4; this is the F statistic referred to below each of the equations.

The model has a recursive structure reflecting the stock-flow theory which underpins its design. The housing stock at the beginning of period t is a predetermined variable that depends, inter alia, upon completions in period t-1. Completions in turn reflect starts prior to t-1. House prices are therefore recursively determined at time t.

Housing starts at time t are affected by current house prices among other variables. However, since current house prices are recursive, so are housing starts. In short, because of the stock-flow structure of the model, random shocks to housing starts do not affect current house prices because of gestation lags in house completions while random shocks to house prices do affect current housing starts. Finally, rents are recursively determined by house prices. We wish to stress that the recursive character of the model is not imposed a priori, but is the outcome of systematic testing. This together with the careful specification of the dynamics of the model and the associated attention to (up to fourth order) autocorrelation suggest that we have not unduly restricted the empirical complexity of the model.

The model that we report is, on the whole, log-linear since this enhanced the goodness-of-fit over the estimation period (1974Q1-1990Q4). However, in section 6 we discuss how more recent data suggest that semi-logarithmic specifications may be superior. The theoretical framework proposed in section 3 is used to guide the estimation of the relevant data generation processes. The selection of specific variables in the empirical model which parallel their counterparts in the theoretical framework is discussed with regard to each equation. For example, equation (4) contains a scale variable, income (Y), which drives housing demand. In section 4.1 we suggest that wealth is empirically superior to disposable income in explaining house prices.

4.1 Real House Prices

Unfortunately, there are no systematic data on vacant housing in which case we cannot model natural vacancy rates, i.e. we cannot estimate equations (2) and (3). Instead we estimate equation (4). We could have solved equations (2) and (3) for the equilibrium rent (R) instead of housing prices in which case equation (4) would have been:-

$$R = R(\overset{+}{Y}, \overset{+}{POP}, \overset{-}{H}) \tag{4a}$$

However, in view of the marginal nature of the rental market and the associated difficulties in imputing rents (see discussion in section 2) we considered it wiser to estimate equation (4) for house prices and thereafter to explain rents in terms of equation (1a).

The rate of interest τ that features in equation (4) consists of two main elements, the market rate of interest (denoted in table 1 by INT) and mortgage subsidies, as discussed in section 2. The more generous the subsidy, from the points of view of both quantity and terms, the lower will be the cost of housing finance and the greater will be the price of housing. The rate of interest is the ex post real rate of interest and therefore reflects the rate of inflation.

The first equation in table 1 is an estimate of equation (4). The inclusion of a lagged dependent variable, see e.g. DiPasquale and Wheaton (1994), reflects either or both of two possible effects: adaptive expectations concerning future house prices or time lags in the response of housing demand to price. There are two policy intervention variables that feature in the equation. The first is the subsidy implicit in mortgages that are subsidized by the government (SUB). It is calculated as the present value of the interest subsidy expressed as a percentage of an average house price. In 1990 the average subsidy amounted to seven percent. The second policy variable (LEV) is the maximum total mortgage from all sources which we express as a percentage of average house prices. This includes subsidized loans and free market loans as limited by the Bank of Israel in consultation with the government. In the past the leverage ceiling was relatively low. For example, in 1980 it was about 40 percent but in more recent years these ceilings have been virtually rescinded. Details of these variables may be found in Bar-Nathan (1988).

We found that wealth performed better than current disposable income. Indeed, it is arguably preferable since wealth is more closely related to permanent income. Finally, equation I includes POP as suggested by equation (4).

The coefficient on lagged house prices in equation I in table 1 implies that there is substantial inertia in house prices. DiPasquale and Wheaton (1994) estimated this coefficient to be approximately 0.8. Since their data are annual while ours are quarterly, there is apparently considerably less house price inertia in Israel than there is in the US.

Letting $P=P_{-1}$ etc. in equation I and solving the result for the housing stock implies equation 7:-

$$\ln H^{D} = \text{constant} - 0.085\ln P + 0.00073SUB + \ln POP + 0.3\ln\frac{W}{POP} + 0.0867\ln SIZE - 0.00018INT + 0.000163LEV \quad (7)$$

Since the housing stock is predetermined it is the net demand for housing that is identified in equation I. Hence equation (7) is the implied long run net demand schedule for housing. It implies that the net demand for housing is proportionate to the (adult) population and varies directly with wealth per capita. It varies inversely with the cost of housing finance as captured by the variables INT, SUB and LEV. The implicit net price elasticity of demand for housing is very small, -0.085. When equation I is solved directly for H without restricting that $P=P_{-1}$, the implied price elasticity of demand is -0.3. These elasticities compare with DiPasquale and Wheaton's (1994) estimates of between -0.09 and -0.19 for the US.

Equation I implies that the short term elasticity of house prices with respect to the housing stock is -3.424 and it is even larger (-11.7) in the longer run. The elasticity (holding all other variables constant) with respect to the adult population is correspondingly 3.424 in the short run and 11.72 in the long run. Interest rates have a weak effect on house prices and at conventional levels INT is not significant.[9] However, housing subsidies (SUB) have significant, positive effects as do leverage ceilings (LEV). The wealth effect per capita (income was not independently significant) is positive and significant and implies that the elasticity of demand for housing with respect to wealth is 0.3 in the long run. The final term in equation I reflects speculative influences on housing demand (Δ^2 denotes the second difference operator) that are expressed by forward values of future population growth.

It should be noted that H represents the number of housing units. Since the average size of these units has grown over time we have included a premium on the average size (SIZE) despite the fact that P is a hedonic price index. It may be the case that as dwellings grew in size their quality improved in such a way that was not captured by the hedonic price index. Hence the inclusion of SIZE may proxy the unmeasured quality of the housing stock. Indeed, it turns out that equation I implies that when "quality" increases by one percent the house price index also rises by slightly more than one percent in the long run. Both in the estimation and simulation of the model we treat SIZE as an exogenous variable.

4.2 Housing Starts

The dependent variable in equation II of table 1 - housing starts - is defined in terms of square meters rather than units. Equation II relates directly to equation (5) where P/COST represents the average unit profitability on building. The presence of the lagged dependent variable is consistent with a partial adjustment model for housing starts, in

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[9] When the same equation is estimated using data up to 1993 Q3 the absolute t value rises to 2.2.

which case short-run responses differ from their long-run counterparts. The short run elasticity of supply of building (with respect to permanent increases) is 0.885 but this falls to 0.49 after two quarters and to 0.35 in the long run. This low elasticity may reflect the inherent riskiness in building when the gestation lag is of the order of two years. By contrast, Topel and Rosen (1988) estimate this elasticity to exceed 2 in the US while DiPasquale and Wheaton (1994) estimate it to be close to unity. On the other hand, Dicks' (1992) estimate for the UK lies closer to ours. We could find no evidence of a levels effect for short term interest rates; only the lagged change in interest rates indicated any signs of significance. In view of the liquidity constraints discussed in Section 3.3 we have included advance sales (X) as an explanatory variable. When the proportion of houses sold in advance (by the time the basic framework is built) rises contractors feel that they can begin new projects with the liquidity that they thereby receive. They may also feel more optimistic about future prospects in the housing market.

PG in equation II denotes the share of the public sector in housing starts which, as mentioned in section 3.5 proxies the net subsidy to new-building. The equation implies that when this share rises by one percentage point total housing starts rise by 1.282 percent in the short run. The specification of equation II implies that public sector starts "crowd-out" and may even "crowd-in" private sector starts in accordance with the discussion in section 3.5. Since $PG = S_g/(S_p+S_g)$ and $S = S_p + S_g$ we may define the marginal "crowding out coefficient" in the short run as:

$$\frac{dS_p}{dS_g} = \frac{1.282(1-PG)-1}{1.282PG+1} \tag{8}$$

Since PG is naturally bounded between zero and one equation (8) implies that the coefficient of crowding out is bounded by 0.282 (when PG=0) and -0.438 (when PG=1).

When PG=½ it is equal to -0.219 implying that one square meter of public sector housing crowds out 0.219 square meters of private starts. The condition for crowding-out is PG>0.22, i.e. the net crowding-out effect starts at PG=0.22 and varies directly with public sector involvement in the housing market. The crowding-out effect is self explanatory. The crowding-in that occurs when PG < 0.22 requires justification. In this case public sector starts complement rather than substitute private starts. Our interpretation is related to capital market imperfections; the preferential financial assistance that contractors receive from the public sector enables them to engage in private starts which were otherwise credit constrained.

Equation (8) expresses the short-term crowding-out coefficient. Its long run counterpart may be obtained by setting $S=S_{-1}$ and by replacing 1.282 by 1.749 = 1.282/0.733.

The final term in equation II indicates that inflation has an adverse effect on housing starts. We suggest two reasons for this. First, real house prices become more uncertain when inflation increases in which case building become riskier. Secondly, the chances of deflationary macroeconomic policy are perceived to increase thereby undermining contractors' business confidence.

As discussed in section 2 the price of land should, in principle, feature in equation II. However, in common with other researchers we are forced to proceed without land price data. DiPasquale and Wheaton (1994) suggest the inclusion of lagged values of the housing stock (H) to capture the effects of land prices. In our case, however, this suggestion is not statistically significant. This is consistent with the hypothesis that ILA has tended to release new building land in line with demand so that real land prices have tended to remain relatively stable.

4.3 House Completions

In section 3.2 we presented a theoretical discussion of building gestation which in terms of the model variables implied that it varies inversely with interest rates and the ratio of house prices to building costs (P/COST). There is no direct expression of the building gestation in the model that we present. However, it is expressed indirectly via the aggregate relationship between completions and starts since the lag between these variables increases with building gestation.

The dynamic relationship between starts and completions is described by equations III.1, III.2 and III.3 in table 1 which form a multi-cointegrated system, see Lee (1992). Equation III.1 defines (up to a constant reflecting unknown initial conditions) the stock of uncompleted buildings (UNF) whose change is simply the difference between starts and completions. Both S (starts) and C (completions) are I(1) variables i.e., they are stationary in first differences; the DF (Dickey Fuller t statistic) statistic for ΔS is -9.9 and for ΔC is -13.5. The DF statistic for UNF is 2.4 in which case we may conclude that UNF $\approx$ I(1). Therefore, equation III.1 may be regarded as the first stage of a multi-cointegrated system.

Equation III.2 describes "normal" completions and implies that in each quarter 12.9 percent of uncompleted new buildings are completed. The constant term reflects an unknown initial condition, i.e. the fact that UNF for 1972Q4 is unknown. C and UNF are both I(1) variables. The DF statistic of equation III.2 suggests that C and UNF are cointegrated. The absence of P/COST~I(1) from equation III.2 implies that the "normal" completion rate is independent of P/R in equation (6), i.e. contractors do not apparently build faster when it is more profitable. Since INT~I(0) interest rates do not belong in the cointegrating regression but they feature in the associated error correction model.

Finally, equation III.3 is the error correction model associated with equations III.1

and III.2. The multi-cointegrated specification implies that all starts are eventually completed. The error correction model captures the short term dynamics of the starts - completions nexus. Figure 9 illustrates the nature of the distributed lag that is implied by the model; it is bi-modal and implies an average lag of 8 quarters. It is calculated using equations III.1, III.2 and III.3 to simulate the effects on completions of 100 additional starts in the first quarter. Clearly this lag distribution does not refer to individual houses because according to figure 2 completions begin to occur almost simultaneously with the increase in starts. Instead it refers to contractors' housing portfolios as a whole rather than individual houses. Equation III.3 implies that contractors delay completion unless they undertake new business.

It further implies that the completion rate varies directly with changes in interest rates because, as noted in section 3.2, this makes delay less profitable but it varies inversely with the level of interest rates. The latter effect is consistent with the hypothesis that when interest rates rise, contractors prefer less capital intensive technologies of building, which, in the nature of things, prolong the time to build. The effects of P/COST (which features in equation (6a) as P/R) are expressed indirectly via the term in lagged starts which, according to equation II, are affected by this variable as discussed in section 4.2. Finally, equation III.3 suggests that the completion rate decreases when public sector starts accelerate. This may reflect administrative delays that are brought about when contractors deal with the bureaucracy or "crowding out" effects. Alternatively, it may reflect less insistence by the Ministry of Housing on deadlines.

In summary equations III.1 - III.3 imply that interest rate shocks and increases in the profitability of building accelerate completions along the lines discussed in section 3.2.

4.4 Advance Sales

Equation II implied that contractors accelerate new building activity once they have succeeded in selling their units in advance, as discussed in section 2. The discussion in section 3.3 suggested that because of capital market imperfections contractors will tend to sell in advance when their cost of capital increases. This effect is expressed directly in equation IV via INT, but it is also expressed indirectly via COST. When building costs increase it becomes implicitly more expensive for contractors to raise capital in which case they prefer to sell in advance. Indirect effects are also captured by the terms in POP/H and house prices (P). When the rate of increase in the former rises and when real house price inflation accelerates contractors seek to engage in new business. However, being credit constrained they raise capital by selling in advance.

Equation IV incorporates a third order lag in the dependent variable suggesting that advance selling responds in a complicated way to contractors' shadow cost of capital. Finally, inflation induces contractors to sell later rather than sooner. This is consistent with the argument that housing serves as a hedge against inflation which induces contractors to remain the owner of real estate for longer.

4.5 Rents

Absence of the relevant data prevents us form desegregating the rental market from the market in owner-occupation, as e.g., in Blackley and Follain (1991). However, the estimation, which is based on equation (1a) implicitly takes account of imperfect substitution between renting and owning. Equation (1a) in section 3 implied that the partial elasticity of rents with respect to house prices should be unity, interest rates should exert a positive influence on rents, while income/wealth most probably exerts a negative effect.

Finally inflation, it was argued, is likely to affect the relation between rents and house prices. While in an imperfect housing market it may be unreasonable to expect equation (1a) to hold in the short run (it clearly doesn't) it may, nonetheless serve as a long run proposition - rents and house prices should be linear homogeneous.

Equation V in table 1 represents our attempt to estimate dynamically the specification suggested in equation (1a). It takes the form of an error correction model in which the rate of change of real rents depends, inter alia, on the rate of change in real house prices as well as the lagged level of the rate of rents to house prices. The equation implies that while inflation affects the rental rate there are no discernable income/wealth effects. On the other hand, rents vary inversely with capital gains on house ownership as suggested in equation (1a).

The long run solution implied by equation V (setting terms in Δ to zero) is:-

$$\ln\hat{R} = \text{constant} + \ln P + 0.0338INT - 0.48INF + 0.16\exp(INF) \tag{9}$$

i.e. there is a unit long run elasticity of rents with respect to house prices, however, while interest rates exert a positive influence on the rental rate (R/P) the effect is considerably less than implied by equation (1a). Finally, equation (9) implies that the rental rate varies with inflation. Both inflation and its exponent affect the logarithm of rents implying that the relationship between rents and inflation is nonlinear and non-monotonic.[10] Equation (9) implies that provided the annual rate of inflation is less than 114 percent the effect of inflation on rents is negative. However, when inflation exceeds 114 percent per year the effect is positive. We interpret this effect along the lines discussed in section 3.4: when inflation is relatively low (recall that in the first half of the 1980s inflation was triple

[10] In Israel inflation peaked at about 450 percent p.a. in 1984/5. The inflation rate in 1994 was 15 percent.

digit) it induces people to prefer to own rather than rent since owing provides a hedge against inflation. At very high rates of inflation renting becomes more attractive because it becomes increasingly difficult to manage the cash flow implications of index-linked mortgages.

The remaining terms in equation V represent short-run dynamics. The implied impulse response elasticities of rents with respect to house prices are as follows:-

	Year			
Quarter	1	2	3	4
1	0.42	0.43	0.68	0.82
2	0.11	0.50	0.72	0.84
3	0.23	0.57	0.76	0.87
4	0.34	0.63	0.79	0.89

i.e. the impact elasticity is 0.42. Part of this effect is lost during the first year after which the elasticity climbs slowly towards unity. After 4 years 89 percent of the adjustment is affected; in the long-run the multiplier is, of course, unity. This slow rate is implied by the final coefficient in equation V (-0.136). However, since this term is both significant and negative it confirms the existence of an error correction model which relates rents to house prices and other variables.

Equations I and V in table 1 have a recursive structure; house prices affect rents but rents do not feed back onto house prices. In the Israeli context this is plausible because renting is a marginal component of the housing market - so house prices affect rents but not vice-versa. Indeed, this recursion is supported more formally by misspecification tests.

5. Simulation Analysis

In table 2 we report the results of a static and dynamic simulation exercises over the period 1977-1990. We report the mean percentage error and the percentage root mean squared error for all variables except advance sales (X) which are expressed as a percentage. The static simulation reveals that the model is relatively noisy, especially for a quarterly model. The calculated mean percentage errors of the dynamic simulation indicate that the model successfully tracks the data over a relatively long time period; there is no evidence of model instability. All the mean errors are not significantly different from zero. For example, the mean error of 4.1 percent in the case of house prices is not significantly different from zero since the RMSE% is 6.2. As might be expected, the dynamic RMSEs are greater than their static counterparts. In summary, the model tracks the data quite accurately over the 14 years under review. Of course, the statistics do not constitute independent misspecification tests beyond those reported in table 1. Nevertheless, they serve to quantify the degree to which the model as a whole tracks the data.

In what follows we characterize the model in terms of its principal dynamic multipliers. Since the model is not linear in variables the calculations are state dependent. The base is in fact drawn from a projection over the period 1991Q1-2000Q4.

Before calculating these multipliers we close the simulation model by endogenizing the average size (SIZE) of dwellings and by making an allowance for demolitions and redesignations. During the estimation period the latter were assumed to be a proportion of starts (see equation VI.3) rather than, for example, a proportion of the housing stock. This reflects the fact that the average age of the housing stock is low because the country is relatively young. Slum clearance is therefore virtually unknown in Israel. Instead, contractors demolish existing structures once planning permission has been obtained to build larger units on existing sites or they build on greenfield sites allotted for building purposes by ILA in which case there would be no demolition at all. Since 1990, as a result of mass immigration to Israel, the vast majority of building has been on greenfield sites so that demolition rates have fallen. In the simulation the baseline demolition profile is therefore assumed to reflect non-greenfield starts only.

We include the following identity:

$$\Delta H^* = C - DEM$$

where DEM denotes demolitions and redesignations and $H^* = H \times SIZE$ denotes the housing stock defined in terms of square meters of dwelling space. Note that equation II of the model incorporates the number of housing units H rather than area, H^*. The identities (equations VI.1-2) at the foot of table 1 describe the way in which we convert the area of housing completions into the change in the stock of housing units. Equation VI.1 assumes that the average size of current completions is equal to the average size of starts eight quarters ago. This assumption reflects the two year average lag in building as discussed above. Equation VI.2 indicates that we take account of the fact that the size of private and public sector starts may differ where w denotes the weight of the latter in the total. Indeed, in the simulations reported below we assume in line with current data that $SIZE_g = 75m^2$ and $SIZE_p = 150m^2$. Finally, equation III.1 implies that the change in the number of uncompleted buildings as starts minus completions. $SIZE_g$ is a policy variable. In principle $SIZE_p$ is an endogenous variable. However, since its role in the model is of a secondary nature we do not further complicate the model by trying to endogenize it. In equation I in Table 1 SIZE is predetermined in which case its inclusion does not induce any misspecification bias.

The econometric estimates indicate that the price elasticity of demand for housing is relatively small, i.e. schedule D in panel I of fig. 1 is indeed downward sloping but steep. This implies that demand shocks will induce large responses in prices. However, the estimates also indicate that contractors' reactions to price changes are positive but small, i.e. schedule S in panel III of fig. 1 is flattish. This implies that demand induced price increases will tend to display considerable persistence since the housing stock adjusts slowly over time. Indeed these features are embodied in all of the simulations that we report and suggest that shocks to the housing market reverberate probably for decades and dissipate very slowly.

The dynamic multipliers of the model are reported in table 3 where simulations A,D and F are demand shocks, simulations C,E and G are supply shocks and simulation B is a shock to both supply and demand. These simulations describe how the model responds to various exogenous shocks in the short and long runs. The demand shock multipliers tend to be similar as do the multipliers on the supply side. In simulation A in table 3 we assume a permanent increase of one percent in the baseline population. The increase in the adult population raises the demand for housing services which via equation I raises house prices by 2.8 percent in the quarter in which the shock is assumed to occur. This price increase intensifies over the first four years on the back of speculative forces which are driven by adaptive expectations. The rise in house prices raises building profitability which induces (via equation II) an increase in starts of 2.4 percent in the first quarter. After some initial overshooting the increase in starts reaches about 3 percent.

Following the gestation lag represented by equations III, the stock of housing begins to increase such that by the end of the period it has grown by 0.6 percent. This is less than the increase in the population so that people are more crowded even by year 10. Indeed, it is partly for this reason that house prices are still 9.6 percent higher even after

10 years. This reflects the aforementioned lackluster response by contractors to enhanced building profits. However, by year 5 the housing stock has grown sufficiently to moderate some of the increase in house prices. House prices peak at 12.9 percent after 4 years indicating that prices rapidly overshoot their new long-run equilibrium.

In simulation B interest rates are raised permanently by one percentage point. Interest rates feature in equations I,II, III.3 and IV in table 1, therefore, their role is quite involved. In the former their effect is to lower housing demand and thereby house prices. In equation II they restrict supply (but only in the short run) which will tend to raise house prices. According to equation III.3 the increase in interest rates accelerates the completion rate in the short run but reduces it in the longer run. Finally, equation IV implies that contractors engage in more advanced selling when interest rates rise in order to obtain substitute liquidity. These conflicting forces are manifest in the behavior of house prices over time which first fall and then rise, i.e. supply effects eventually predominate over demand effects. However, the effect on the housing stock is unambiguously negative despite the fact that starts change direction twice. Not surprisingly, higher interest rates lead to a lower equilibrium housing stock.

Simulation C is defined in terms of a one percent rise in public sector starts. In the base run these are high in the early 1990s (to cope with the wave of immigration) but low in the second half. Our calculations are therefore more than usually base-dependent especially in relation to starts, since according to equation (8) the "crowding-out" effect is non-monotonic. It is for this reason that the multipliers for starts change signs in the latter half of the simulation. This apart, the simulation conforms to expectations; the increase in public starts stimulates new building which eventually raises the housing stock, thereby exerting downward pressure on house prices.

When mortgage subsidies are raised the demand for housing increases thus raising house prices, which, in turn, stimulates new building. The quantification of these effects is presented in simulation D where the subsidy is permanently raised by one percentage point. House prices peak in year 4, i.e. in common with simulation A which is also a demand shock. Therefore the logic of simulation D is broadly the same as in simulation A. Indeed starts in both simulations level off in year 4 and decline thereafter. This reflects the behavior of prices which peak in year 4. Mortgage subsidies induce a relatively large price reaction, which by year 4 has eaten into 81 percent of the value of the subsidy, and a relatively small supply response. The housing stock has risen by only 0.04 percent after two years.

The lackluster supply response implies, on the other hand, that contractors will not be sensitive to increases in building costs. This feature of the model is illustrated in simulation E in which building costs are assumed to rise by ten percent. As might be surmised from equation II in table 1 the short run supply response is relatively strong; starts immediately fall by 6.36 percent. However, this settles down fairly promptly to some 2.5 percent. The housing stock begins to fall relative to the baseline which drives up housing prices. After ten years the housing stock has declined by about half a percent and house prices rise by 3.8 percent in real terms. As house prices progressively increase the initial fall in building profitability of ten percent is partially reversed. By year ten the fall in profitability is 6.2 percent. It is for this reason that by the end of the period the fall in starts is 1.95 percent rather than 2.31 percent as in year 3.

In simulation F private sector wealth is assumed to rise by one percent. This raises the demand for housing because agents hold houses as part of their extra wealth. The increase in demand raises house prices by 1.03 percent initially which induces increased building activity. Because the simulation consists of a demand shock its logic is similar to that in simulation A. Thus house prices peak in year 4 and begin to fall once the housing stock has increased sufficiently to offset the increase in demand, i.e. as in simulations A and D which are also demand shocks.

Finally in simulation G we assume that the average building lag is reduced by 25%. This is engineered by raising the coefficient on UNF in equation III.2 from 0.129 to 0.2. This simulation is of interest because in 1990-1992 the government induced contractors to reduce the time to build in the face of the current wave of immigration from the CIS. Because dwellings are completed faster the housing stock is raised by 1.11 percent after 5 years. The extra supply lowers real house prices from what otherwise have been the case which in turn has an adverse effect on new building activity. This is sufficiently large such that by year 9 of the simulation the housing stock has started to decline and continues to year 10. As a result house prices begin to rise (2.75 percent in year 10) which in turn begins to stimulate new building. In short, cutting the time to build raises the housing stock in the short run (6 years) and triggers a cycle in house prices and construction. In the very long-run, however, the housing stock and house prices will not be affected since the shock only affects the timing of completion.

6. Conclusion

We have estimated and presented a structural econometric model of the market for housing in Israel. The model explains the dynamics of the housing market in which the principal endogenous variables are house prices, starts, completions, the housing stock and rents. The key exogenous variables which drive the model are population, wealth and the cost of building inputs. Policy variables include public sector starts and their size, interest rates and mortgage subsidies to owner-occupiers.

The stock-flow specification of the model combined with the small elasticities of supply (flow) and demand (stock) that were estimated imply that house prices respond sharply to demand shocks, that price shocks display considerable persistence and that overshooting of both prices and construction is to be expected. As far as we can make out the elasticity of supply, while small, is not greatly out of line with estimates found in other countries, with the exception of the results of Topel and Rosen (1988). The small price elasticity of demand has been observed elsewhere too, see Meen (1993). Therefore, the parameter estimates for Israel may be approximately applicable in other countries. If so, this suggests that housing markets have complicated dynamics with shocks that continue to reverberate long after they have become history.

In the 1990s Israel has experienced a major wave of immigration. Since 1989 when the population stood at about 4½ million some 600,000 immigrants have arrived and the population has grown by about 20 percent (there has been considerable natural increase too). The model implies that both house prices and building will rise because there have been cumulative shocks of type A in table 3. However, the public sector has renewed its involvement and subsidized public sector starts increased sharply to stimulate new building. In practice real house prices have risen by some 50 percent since 1989 (and continue to climb at the time of writing) from a base that was already historically high and housing construction has increased sharply. Indeed, so far the outside sample performance of the model as a whole has been quite good. When re-estimated with data up to the end of 1993 equation II,IV and V in table 1 easily pass Chow tests. The structure of equation 1 is retained if, in the light of survey data, it is assumed that new immigrants initially live in more crowded conditions than the incumbent population (i.e. the adult population (POP) is appropriately adjusted downward for crowding) so that housing demand is reduced during the period of "acclimatization". The structure of equations III (the starts-completions nexus) is retained too if account is taken of the policy to provide generous incentives in 1990-92 to curtail the time-to-build in the public sector. A further detail is that in equations I and II it is preferable to specify the dependent variable in levels instead of logarithms, implying that elasticities are not constant and vary inversely with the level of the explanatory variables.

The model implies that supply-side policies work more slowly on house prices than do demand-side policies. Compare for example simulations D (a demand-side policy) and E (a supply-side shock). Prices respond more quickly in the former case because demand is price inelastic and the stock of housing is fixed in the short run. Prices respond slowly in the latter case because not only is the supply elasticity of new building small, but also because the flow is a small proportion of the stock and it takes time before the new building is completed.

We conclude with some further suggestions for research. The gestation lag in building has played a central part in the dynamics of the model. It most probably makes sense to disaggregate the gestation processes for the public and private sectors, while taking account of the interdependence between these processes. Likewise it may make sence to disaggregate the housing market into "large" housing units and "small" housing units, since there may be some degree of segmentation between these two parts of the market. On the whole, however, we feel that the basic structure of the model is sound having survived Chow tests for structural breaks in 1989 and 1990 and having coped well with the "immigration shocks" of the 1990s. Finally, attention needs to be paid to the assimilation of immigrants into the housing market since the evidence for the 1990s suggests that immigrants behave quite differently from incumbents. In their first year in Israel adult immigrant housing density is 50 percent greater than that of incumbents. However, by their fourth year in the country this falls to about 20 percent. This implies that the effects of immigration shocks on the housing market are smoothed over time and continue to reverberate for a number of years.

Table 1

Model Listing

I. Real House Prices (1974Q1 - 1990Q4)

$$\ln P = 17.78 + 0.00252\, SUB_{-1} + 0.708 \ln P_{-1} + 3.424 \ln(POP/H) +$$

(6.82) (3.66) (12.92) (7.7)

$$1.029 \ln(W/POP) + 0.297 \ln SIZE - 0.00062 INT + 0.00056 LEV + 2.77 \Delta^2 \ln POP_{+8}$$

(12.55) (1.79) (0.9) (2.04) (4.18)

$R^2 = 0.9694$ $\phi = 0.0277$ LM = 16.46 F = 1.12

II. Housing Starts (1975Q1-1990Q4)

$$\ln S = 4.82 - 0.0035 \Delta INT_{-2} + 0.397 \Delta X + 0.267 \ln S_{-1} + 0.885 \ln(P/COST)$$

(9.66) (1.41) (1.15) (3.63) (3.45)

$$-0.628 \ln(P/COST)_{-1} + 1.282 PG - 0.062 INF_{-3}$$

(2.26) (10.69) (4.19)

$R^2 = 0.8238$ $\phi = 0.0964$ LM = 8.3 F = 2.62

III. Housing Completions (1974Q1-199Q4)

III.1 $$UNF \equiv \sum_{i=1}^{\infty} (S_{t-i} - C_{t-i})$$

III.2 $$C = 1124.5 + 0.129 UNF + u$$

$R^2 = 0.364$ DF = -3.4

III.3 $$\Delta C = 3.35 - 0.423 \Delta C_{-1} + 0.143 \Delta S_{-3} - 0.261 u_{-1} + 5.077 \Delta INT -$$

(0.31) (4.91) (2.93) (4.22) (3.11)

$$3.155 INT - 79.16 \Delta SG_{-1}$$

(2.04) (2.45)

$R^2 = 0.559$ $\phi = 68.81$ LM = 2F0‡ 1.63

IV. <u>Advance Sales (1974Q1-1990Q4)</u>

$$X = 0.126 + 0.36X_{-1} + 0.339X_{-2} - 0.19X_{-3} + 2.82\Delta\ln(POP/H)$$
(4.88) (3.11) (2.47) (2.02) (2.38)

$$+ 0.137\Delta^2\ln P_{-2} + 0.26\Delta\ln COST_{-1} + 0.27\Delta\ln COST_{-2} - 0.026INF$$
(1.61) (2.43) (2.29) (2.43)

$$+ 0.0029INT$$
(3.79)

$R^2 = 0.8234$ $\phi = 0.0282$ $LM = 11.67$ $F = 0.68$

V. <u>Rent (1973Q1-1990Q4)</u>

$$\Delta\ln R = 0.0365 + 0.0046INT + 0.0022EXP(INF)_{-1} - 0.06729INF_{-1}$$
(2.28) (2.86) (2.27) (3.39)

$$-0.583\Delta\ln P - 0.384\Delta\ln P_{-1} - 0.136\ln(R/P)_{-1}$$
(3.58) (2.25) (3.37)

$R^2 = 0.54$ $\phi = 0.054$ $LM = 4.64$ $F = 0.51$

IV. Identities

$$\text{VI.1} \qquad \Delta H = \frac{C}{SIZEA_{-8}} - \frac{DEM}{SIZE_{DEM}}$$

$$\text{VI.2} \qquad SIZEA = wSIZE_{g} + (1-w)SIZE_{p}$$

$$\text{VI.3} \qquad DEM = 0.0816S$$

Notes:

"t" values are indicated in parentheses.

ϕ denotes the equation standard error.

LM is the lagrange multiplier statistic for testing fourth order autocorrelation

F is the Chow statistic for equation stability over the period 1989Q1-1990Q4. A separate dummy variable is specified for each of the eight quarters.

DF denotes the Dickey-Fuller statistic for testing cointegration.

Δ^{n} denotes the n'th difference operator.

Glossary of Terms

P	Index of house prices deflated by CPI
SUB	Present value of mortgage subsidies: percent of average house price
POP	Population aged 20+
H	Housing stock: number of units (at beginning of quarter)
H^*	Housing stock - square meters (=H * Size)
W	Real wealth of private sector (at beginning of quarter)
SIZE	Average dwelling size (stock) - square meters
SIZEA	Average size of starts - square meters
$SIZE_g$	Average size of public sector starts - square meters
$SIZE_p$	Average size of private sector starts - square meters
$SIZE_{DEM}$	Average size of demolitions - square meters
INT	Rate of interest (real CPI adjusted) on bank overdrafts, % p.a.
LEV	Borrowing limits - % of house price
S	Housing starts - square meters ($S = S_p + S_g$)
S_p	Private sector housing starts - square meters
S_g	Public sector housing starts - square meters
X	Percentage of dwellings sold by the time the framework is completed
COST	Index of building costs (labor and raw materials) deflated by CPI
PG	S_g/S
INF	Inflation (CPI), % p.a. (year on year)
UNF	Uncompleted dwellings (at beginning of quarter)
SG	S_g/S_p
R	Index of rents deflated by CPI
DEM	Demolitions and redesignations - square meters
C	Housing completions - square meters

NOTE: square meters are measured in units of a thousand.

Table 2

Simulation Errors (1977Q1-1990Q4) Percent

	Static		Dynamic		
	Mean Error	RMSE	Mean Error	RMSE	R^2
Starts	-0.1	7.5	1.1	8.3	0.87
Completions	1.1	7.2	2.2	8.1	0.69
Prices	0.1	2.6	4.1	6.2	0.85
Advance Sales	-0.04	2.7	-0.2	3.5	0.73
Housing Stock	-	-	-0.3	0.4	0.99

Table 3

Dynamic Multipliers (% Change from Base Run)

YEAR	A			B			C			D		
H (Q1)	P	S	H	P	S	H	P	S	H	P	S	H
1	2.8	2.4	0.0	-0.06	0.04	0.0	0.0	0.34	0.0	0.25	0.14	0.0
2	9.2	2.1	0.01	-0.14	-0.03	-0.01	0.0	0.41	0.01	0.7	0.17	0.0
3	11.8	2.7	0.05	-0.14	0.0	-0.03	-0.15	0.35	0.02	0.8	0.18	0.0
4	12.9	3.1	0.12	0.11	0.05	-0.04	-0.3	0.25	0.03	0.81	0.19	0.01
5	12.7	3.1	0.2	0.24	0.08	-0.06	-0.45	0.15	0.04	0.77	0.2	0.01
6	12.0	3.2	0.29	0.32	0.1	-0.06	-0.57	0.03	0.05	0.73	0.2	0.02
7	11.4	3.1	0.38	0.35	0.1	-0.06	-0.64	-0.02	0.06	0.69	0.19	0.03
8	10.7	3.0	0.46	0.35	0.1	-0.06	-0.69	-0.05	0.06	0.64	0.18	0.03
9	10.1	2.8	0.53	0.32	0.09	-0.05	-0.7	-0.06	0.06	0.61	0.17	0.04
10	9.6	2.7	0.59	0.30	0.08	-0.05	-0.2	-0.06	0.06	0.58	0.17	0.04

YEAR	E			F			G		
(Q1)	P	S	H	P	S	H	P	S	H
1	0.0	-6.36	0.0	1.03	0.59	0.0	0.0	0.0	0.0
2	0.11	-2.65	-0.03	2.91	0.72	0.01	-0.42	-0.22	0.11
3	0.44	-2.31	-0.08	3.31	0.75	0.02	-0.42	-0.95	0.47
4	0.87	-2.32	-0.15	3.32	0.80	0.04	-5.93	-1.95	0.89
5	1.42	-2.34	-0.23	3.19	0.81	0.06	-8.61	-2.62	1.11
6	2.01	-2.40	-0.32	3.01	0.83	0.09	-9.20	-2.67	0.99
7	2.57	-2.27	-0.39	2.83	0.80	0.11	-7.48	-1.85	0.58
8	3.07	-2.15	-0.45	2.66	0.76	0.13	-4.15	-0.65	0.06
9	3.47	-2.04	-0.50	2.51	0.72	0.15	-0.40	0.45	-0.41
10	3.80	-1.95	-0.53	2.38	0.68	0.16	2.75	1.22	-0.72

Key (to table 3)

A	1% rise in population
B	1% p.a. rise in interest rates
C	1% rise in public sector starts
D	1 percentage point rise in mortgage subsidy
E	10% rise in building costs
F	1% rise in wealth
G	Fall in time to build from two years to 1½ years

P	real house prices
S	starts
H	housing stock

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FIG.1 REAL HOUSE PRICES
(1985Q1=1)

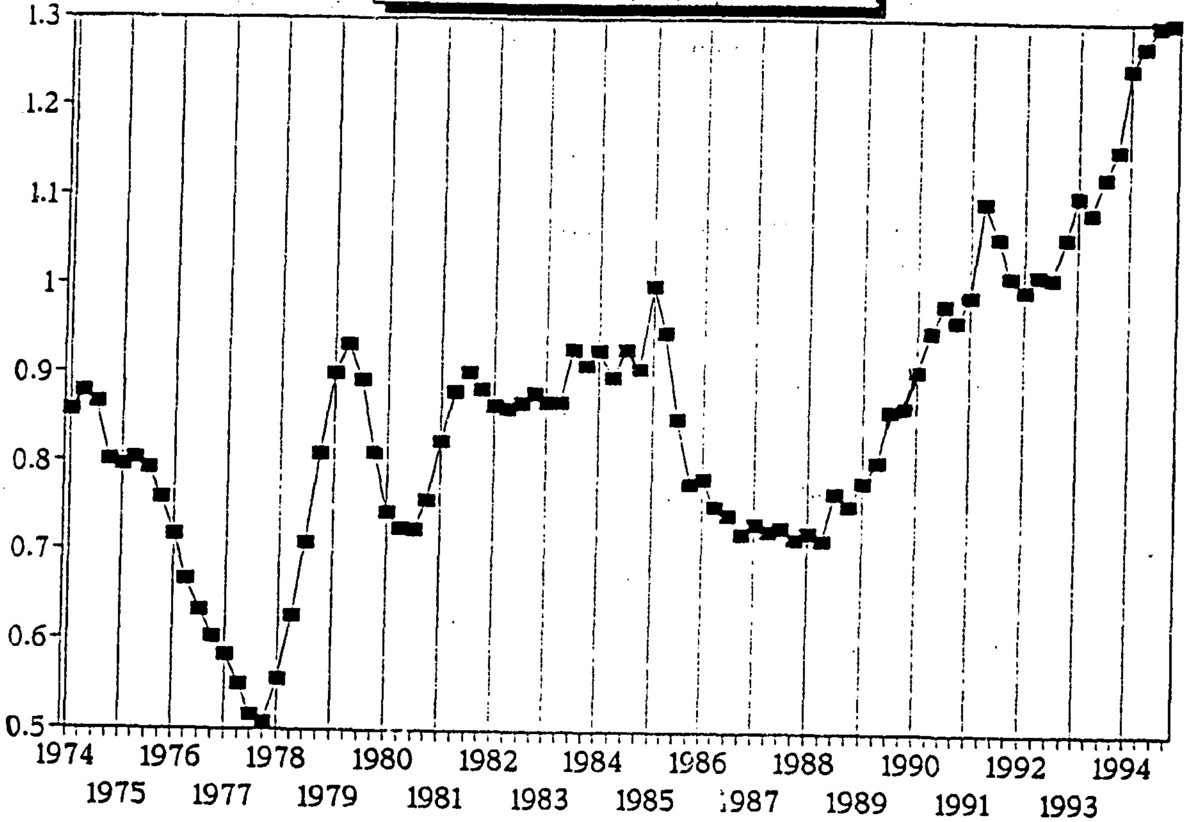


FIG.2 HOUSING STARTS
SQUARE METERS (1000'S)

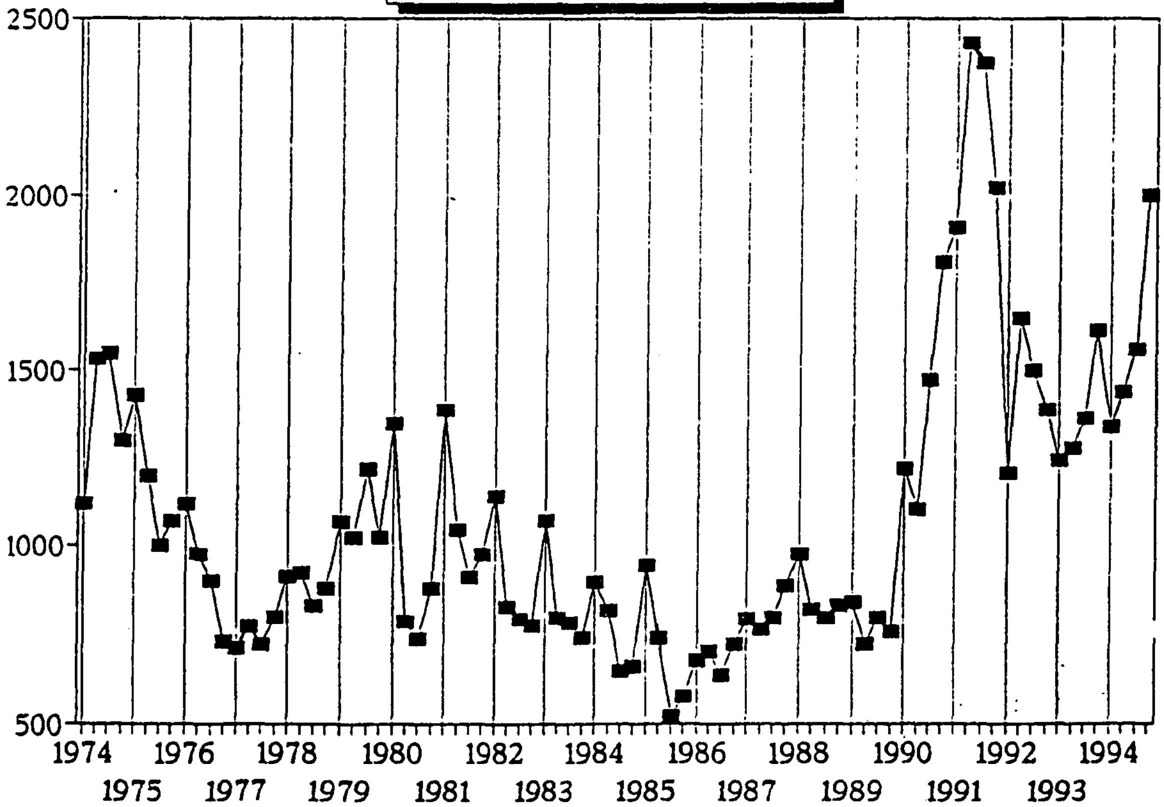


FIG.3 REAL BUILDING COST
(1985Q1=1)

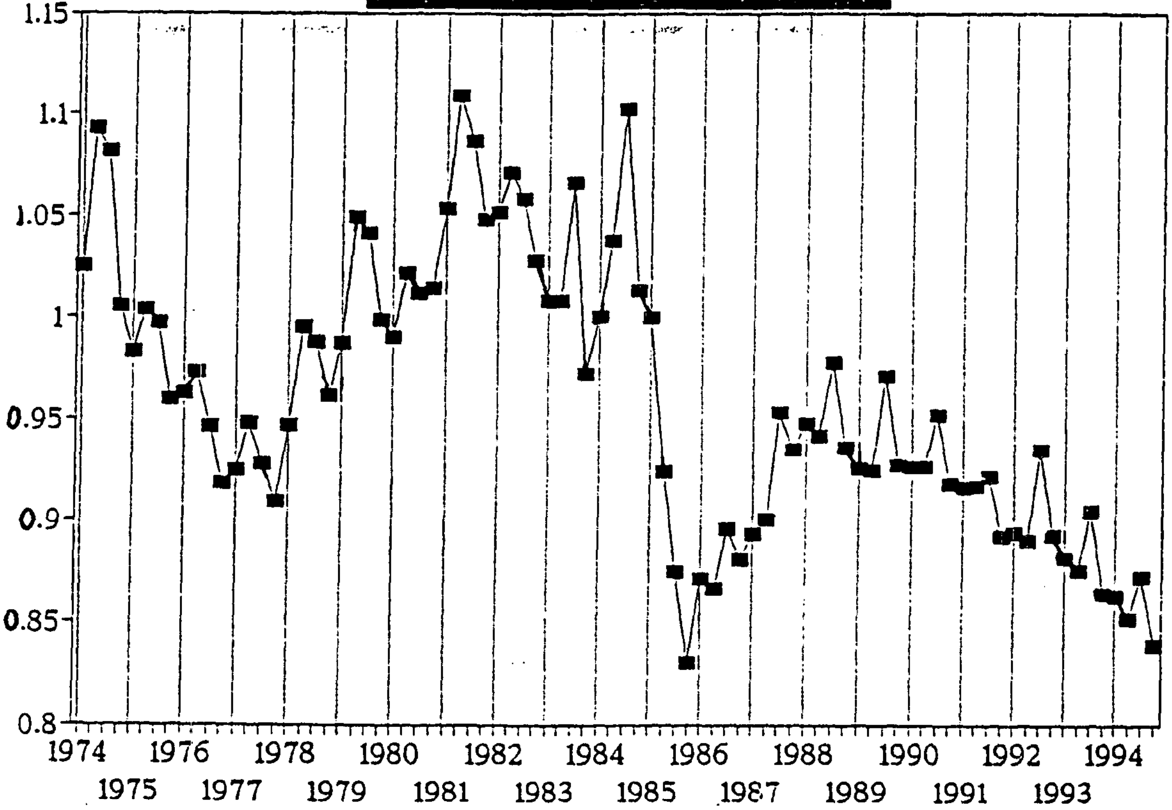


FIG.4 PERCENTAGE OF PUBLIC SECTOR START

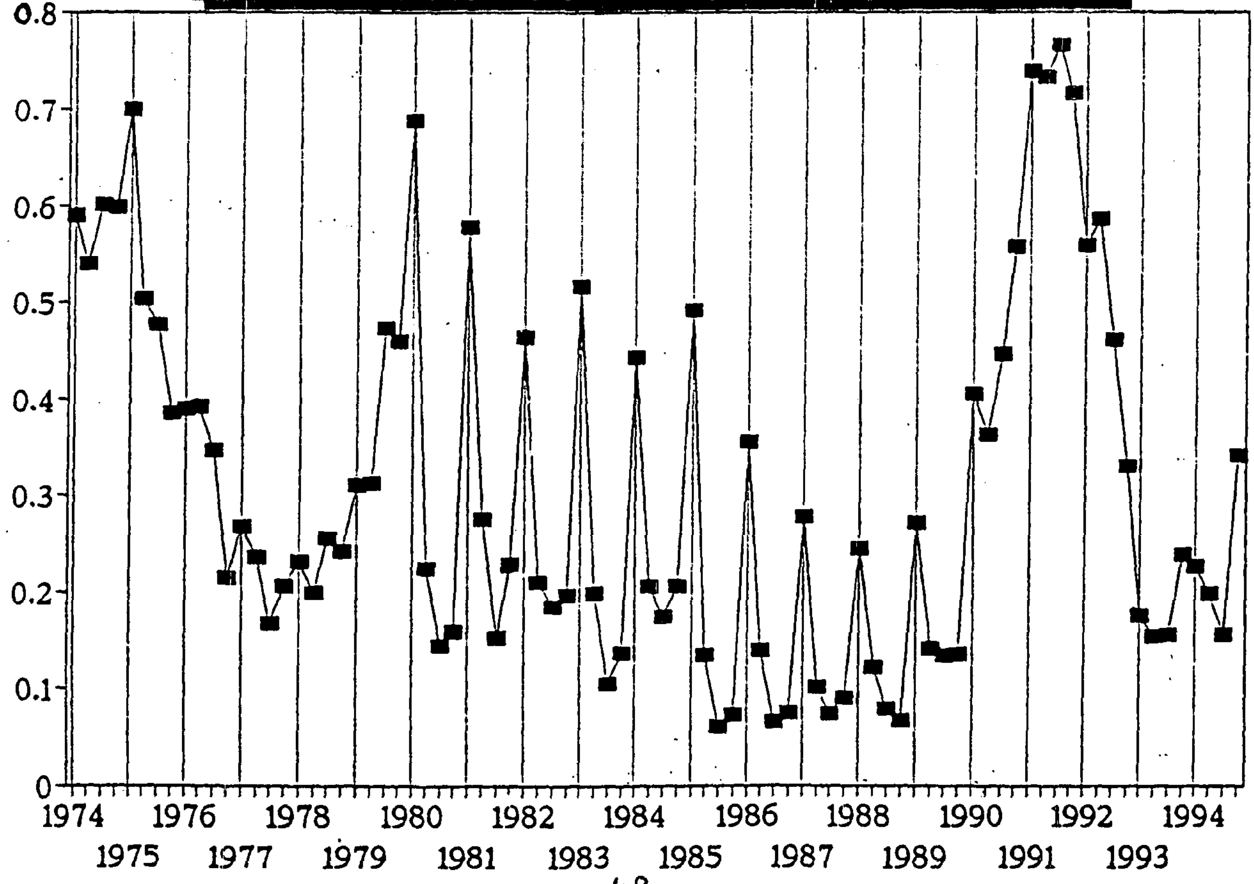


FIG.5 PERCENTAGE OF HOUSES SOLD IN ADVANCE

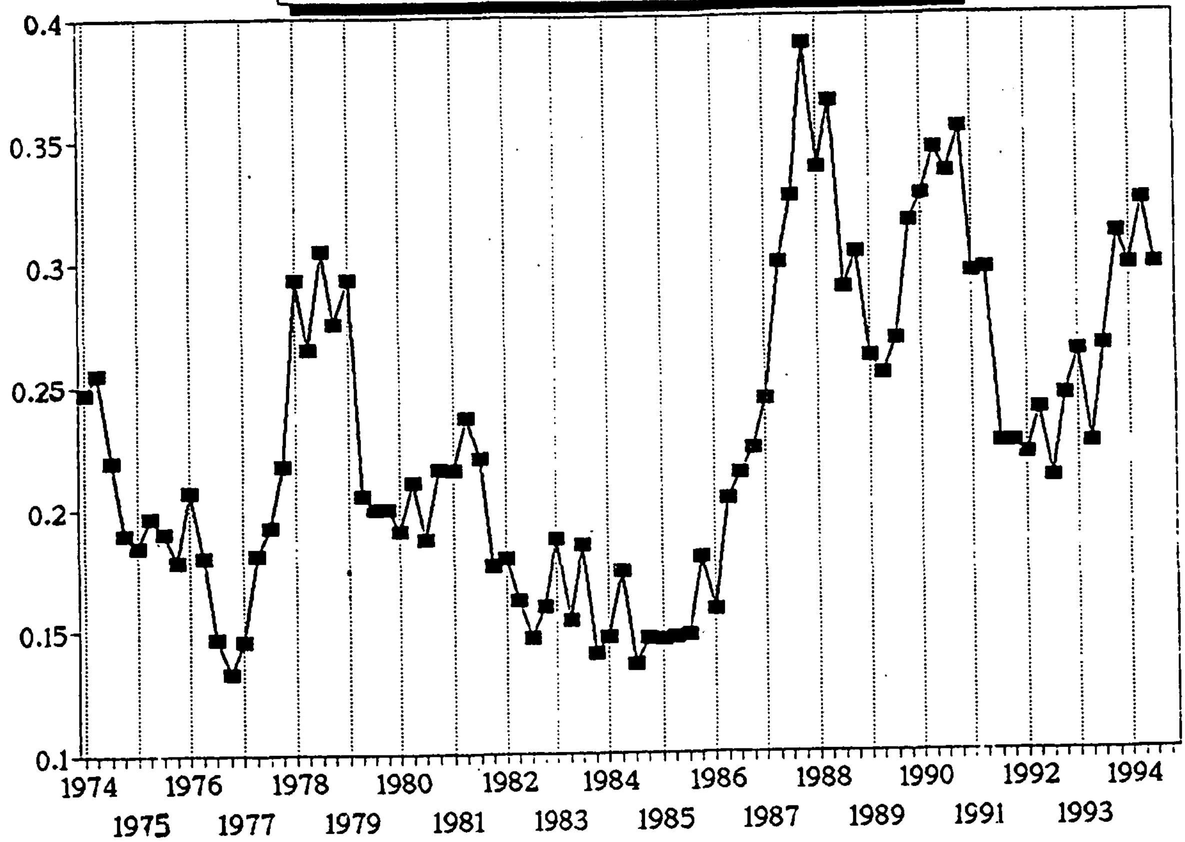


FIG.6 HOUSING SPACE PER ADULT (SQUARE METERS)

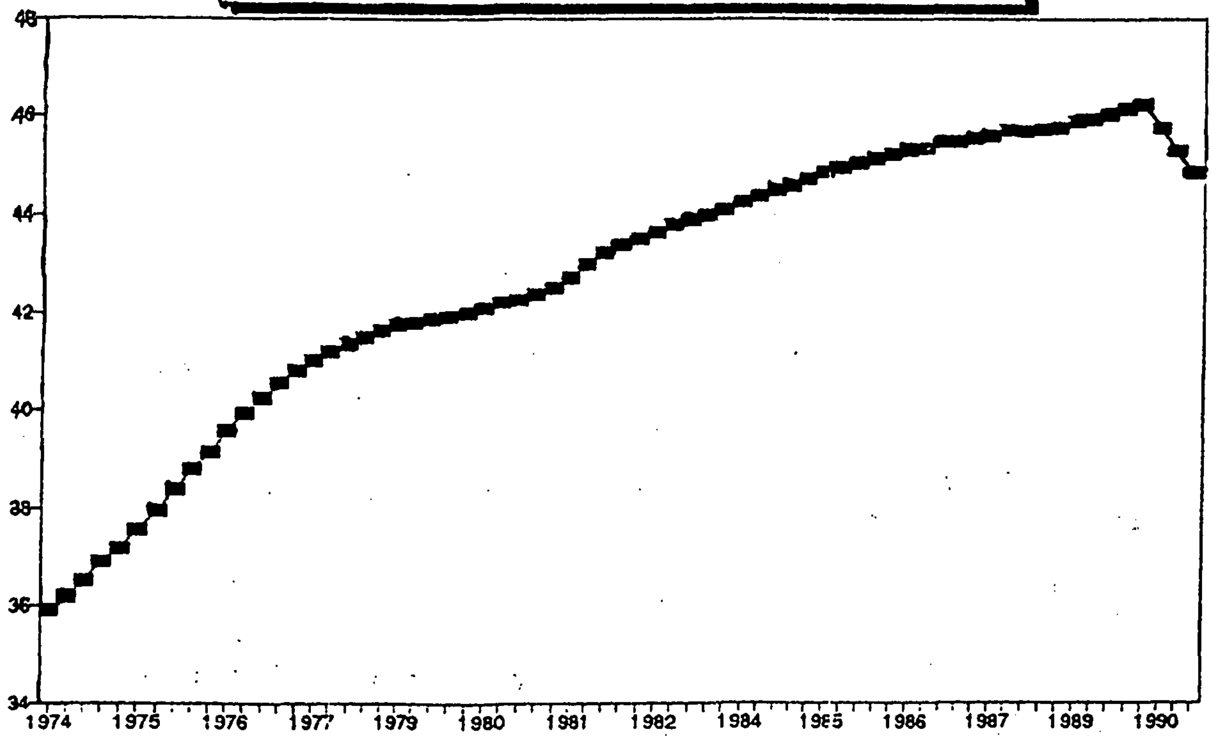


FIG.7 HOUSING UNITS PER ADULT

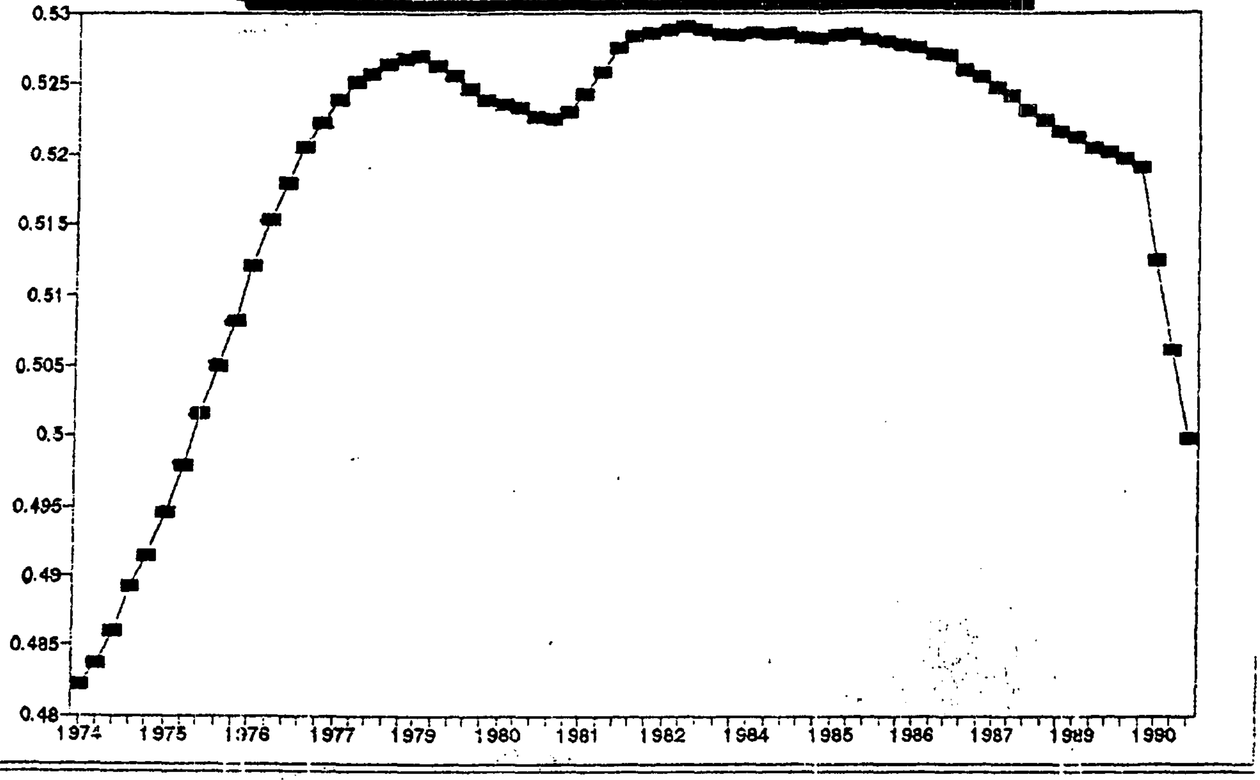


FIG.8 REAL RENT
(1985Q1=1)

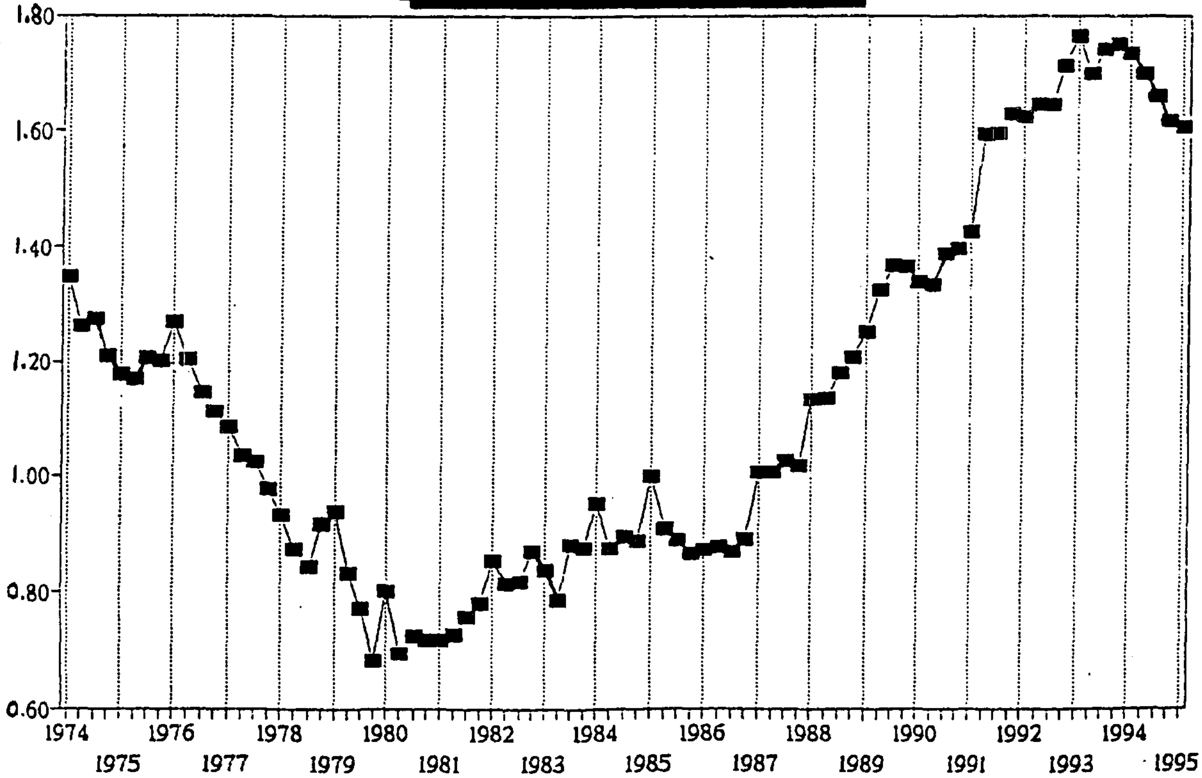
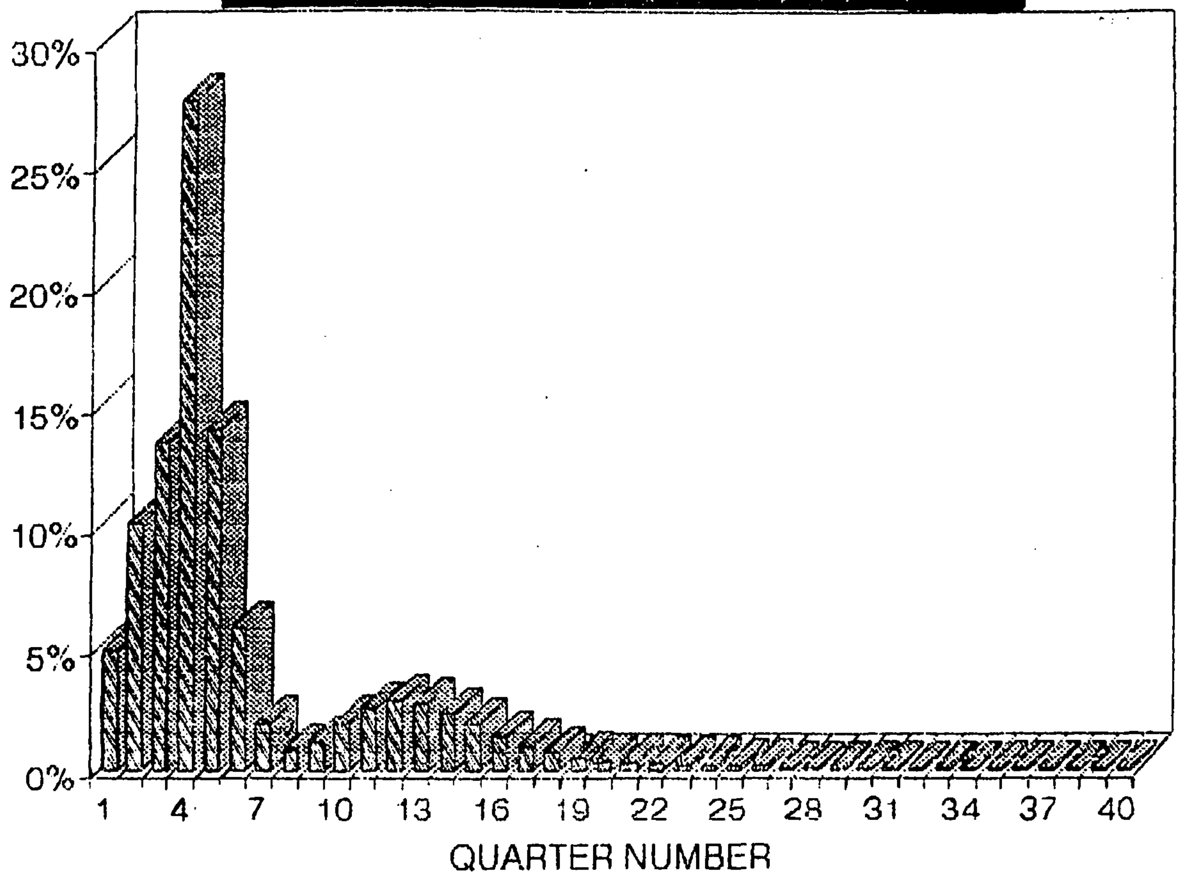


FIG.9 BUILDING LAG DISTRIBUTION



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