An Integrated Property Market Model: A Pedagogical Tool

Dominique Achour-Fischer*

Executive Summary. The Fisher-Di Pasquale-Wheaton model is an elegant metaphor of the integration of the property market, capital market and construction activity. This model was presented in previous articles and officialized in one of the best textbooks in property economics (Di Pasquale-Wheaton, 1992). This article briefly describe the model and shows how it can be used as an interactive pedagogical instrument that facilitates the simultaneous introduction of theoretical modeling, Excel simulations and familiarization with web document interactions. The original version of this article can be used interactively at: www.cbs.curtin.edu.au/units/ef/property/.

Introduction

The first complete description of the Fisher-Di Pasquale-Wheaton model was offered in 1992 (Fisher; 1992; and Di-Pasquale-Wheaton, 1992. The most detailed treatment can now be found in a seminal textbook by Di Pasquale and Wheaton (1996). The instrument was recently applied to the description of Hong Kong housing market by Renaud, Pretorius and Pasadilla (1997).

The Fisher-Di Pasquale-Wheaton (FDW) model will be described briefly here as most of the interactive elements are better explained by accessing the website and using the interactive illustrations. The original article can be found at: www.cbs.curtin.edu.au/units/ef/property/.

As this article is of a pedagogical nature, the point is not to provide a detailed discussion of the model itself, but rather to show how it can be used to explore and quantify some interesting real estate economics topics. This article does not add to the body of knowledge but, in the spirit of JREPE objectives, its intent is to present a useful innovative teaching technique.

The Pedagogical Interest of the FWD Model

One of the challenges of courses in urban economics taught to real estate students is to convince them that basic urban economics can facilitate their understanding of real estate price formations. The FWD model provides a major advantage in this respect since, probably for the first time in their curriculum, students have a chance to observe directly the formalization of interactions between urban markets (employment and required space), capital markets, annual construction and annual stock adjustments. The model is restricted here to office building activities, but it can be profitably extended to housing demand and construction.

---

*Curitn Business School, Perth, Western Australia or Achourd@cbs.curtin.edu.au.
At this stage of most urban economic courses, after a painful but meritorious effort to impress the students with the elegance of the Von Thunen-Alonso model, you may glean a fair amount of “sparkle-in-the-eyes” with the intuitive construction of the FWD framework and, mostly, in the computer labs, when students realize that can simulate their own local market conditions.

The Static Model

In equilibrium, the supply of property should be equal to the demand at various levels of prices. Prices for property assets paid by buyers are a direct function of real or imputed rent. Thus, the relationship between willingness to pay for a certain level of rent is translated in a property value when, on the capital market, anticipated streams of real or imputed rent are capitalized (at the appropriate capitalization rate).

The supply of new property assets is triggered by the difference between property value (determined by capitalized rent) and replacement costs. Any gap between replacement costs and property value acts as a signal for construction activity.

Since part of the stock of property assets is subject to demolition, withdrawal or deterioration, a certain volume of construction is required to maintain the stock at the required equilibrium level even in strictly static conditions.

The main pedagogical advantage of this model is that students have a clear picture of the interaction between financial markets and real assets markets. One of the differences between standard urban economics courses and real estate economics courses is the importance of linking the spatial demand/supply dynamic and asset values. This may be easy to explain in words and stories but not so easy to quantify. That’s where the FDW metaphor becomes quite useful. The complete market interactions are illustrated as a four-panel graph (see Exhibit 1).

Quadrant 1: The Demand Function on the Market for Space. In a strictly static world, new demand for space comes from users (residential, industrial or commercial). These users need to maintain the same level of space services that may have been reduced by demolition, withdrawal or demolition. With a static supply, the price of space (rent) increases if demand for space services increases and conversely.

This quadrant (see Exhibit 2) is a good place to help students review the concept of a negative sloped demand curve and concepts of elasticity. The Excel table linked to this panel provides the opportunity of manipulating the demand curve and relating it to the basic formula of a linear model. Many other questions can be raised at this point: the number and space used by office workers, rent levels and other economic factors that can explain the level of demand.

In Di Pasquale–Wheaton, the demand for office space is written as: $S = E(400 - 10R)$. Where $S$ (the supply) is equal to the demand and determined by $E$ (the number of office workers = 10 millions) who utilize 240 sq. ft. per capita. The level of rent is $16 per sq. ft.
Once students understand the various components of this formula, they are invited to find reasonable parameters for their own local markets. This in itself is a major challenge. Realistic numbers are not so easily extracted from most first-year students. But, of course, this is when they are invited to collect their own information and to explore basic sources.

The various parameters illustrated in the website example of Perth (Western Australia) are more or less realistic. Real numbers should not be provided directly to the students, as they should try to find the information for themselves.
**Quadrant 2: The Valuation Function:** Rent ($R$) is transformed into a market value by discounting at the capitalization rate ($i$). Thus, $P = R/i$. This quadrant (see Exhibit 3) is another good mine of discussions on the meaning and measurement of capitalization rates. First-year students are still unfamiliar with this concept so the explanation must remain quite basic. Essentially, students should be able to develop a good intuitive understanding simply by manipulating the slope of the curve in the graph.

The mirror imaging of the curve (flipped around the rent axis) seems to create some interpretation problems. It may be useful to spend some time on this issue at this stage as; this “flipping-of-the-curve-problem” arises again with the next two panels.

Another delicate point is the explanation that the capitalization rate should be adjusted to reflect real interest rates. In Di Pasquale–Wheaton, a real rate of 5% was chosen. This requires some explaining and here again, the discussion would be more fruitful for second- or third-year students. Various illustrations of the relationship between interest rates and the volume of construction could also be presented at this stage.

**Quadrant 3: The Construction Function.** The volume of construction is a function of assets market price. Construction will take place when market prices are above construction costs; otherwise, construction comes to a halt. Thus, simply: $P = f(C)$. The functional relationship in the textbook is: $P = (200 + 5C)$, which leads to the calculation of the volume of construction: $C = (P - 200)/5$.

Here, many topics can be treated, such as:

- The concept of the minimum justifiable construction price explains that the curve does not start at the origin. Some approximate local numbers could be discussed for different types of construction.
The concept of construction supply inelasticity.

An explanation of parameters and their relationships to real construction figures.

An explanation of construction cycles and the stickiness of supply reaction to shifts in prices and demand.

Querying the straight-line simplification of the construction function.

Nature and structure of the construction industry and its local idiosyncrasies.

Special attention must be given here to the proper interpretation of this part of the graph as both axes are inverted (see Exhibit 4). This upside down reading of the graph may create some difficulties (much less for Australian students who are accustomed to reading world maps upside down).

**Quadrant 4: The Adjustment Supply.** This quadrant (see Exhibit 5) describes how the annual volume of construction replaces the depreciated or withdrawn part of the existing stock. Construction for replacement is a constant percentage of the existing stock in a static model: \( C = S/d \) and the annual construction makes up the variation of the stock. Thus, \( \Delta S = C - dS \).

This part of the graph raises questions about the reasons for stock depletion, different issues related to depreciation and stock adjustments in the commercial, industrial, and residential sectors (see Exhibit 6). Some approximate numbers should also be discussed in class (in the textbook, a depreciation rate is set at 1%).

**The Full Model**

“Putting Humpty Dumpty together again” is the gratifying part of the exercise. The full four-quadrant static model is reconstructed to look like the four-quadrant model.
we started with. Now that students have a complete picture of the various markets, it makes intuitive sense for them to write the simultaneous equations model as:

\[ R = f_1 (S) \quad \text{Demand for space;} \]
\[ P = f_2 (R) \quad \text{Determination of value;} \]
\[ C = f_3 (P) \quad \text{Construction function; and} \]
\[ S = f_4 (C) \quad \text{Stock adjustment function.} \]

Or, in reduced form:

\[ S = E(b - a \cdot R); \]
\[ P = R/H; \]
\[ C = (P - \beta)/\alpha; \text{ and} \]
\[ C = S/d. \]

Where \( b \) and \( a \) are the parameters describing the demand function and \( \alpha \) and \( \beta \) represent the construction function.

Resolution of this system of equations seems to be beyond most first-year real estate student’s capabilities and the required solutions must be provided since the Di Pasquale–Wheaton textbook is quite laconic on this point.

Formulas used in the spreadsheet are:

\[ S = E*(b - a * i * \beta)/(1 + E * a * i * \alpha * d); \]
\[ R = (b/a) - S/(a \cdot E); \]
\[ P = R/i; \]
\[ C = (P - \beta)/\alpha; \text{ and} \]
\[ C = S/d. \]

Now students should be able to rewrite all the tables and manipulate all the parameters to examine the relationships between variables. This part of the exercise is quite gratifying since students realize that everything fits without having to struggle with the math.

Of course, to reach the proper calibration they may have to cheat by using the Goal function of Excel. However, this trick should not be pointed out too early. Users need
to experiment as much as possible and get closer to some equilibrium by educated iterative guesses.

### The Dynamic Model

When students feel comfortable with the various links between quadrants and have a reasonable intuitive understanding of the model structure, they are ready to juggle different curves. A good place to start is by shifting the demand curve (with an
Exhibit 9
Interactive Static Model

Perth, with a shift in demand....

\[
P = \frac{R}{I}
\]

\[
P = f(C)
\]

Stock \( S = E \cdot (b - woR) \)
Number of office workers \( E \) = 100,000
Rent \( R \) = 201.78 $/sq.meters
Space per worker \( S/E \) = 16.44 sq.meter per worker
Parameter \( a \) = 2
Parameter \( b \) = 420

The straight line represents the function:
\[
R = \frac{b}{a} - \frac{1}{a} * \frac{S}{E}
\]

slope \( \frac{1}{a} \) = 0.5
Y-axis \( \frac{b}{a} \) = 210

<table>
<thead>
<tr>
<th>Demand for space (sq. meters)</th>
<th>Rent ($ per sq. meter)</th>
</tr>
</thead>
<tbody>
<tr>
<td>22,000,000</td>
<td>100</td>
</tr>
<tr>
<td>20,000,000</td>
<td>110</td>
</tr>
<tr>
<td>18,000,000</td>
<td>120</td>
</tr>
<tr>
<td>16,000,000</td>
<td>130</td>
</tr>
<tr>
<td>14,000,000</td>
<td>140</td>
</tr>
<tr>
<td>12,000,000</td>
<td>150</td>
</tr>
<tr>
<td>10,000,000</td>
<td>160</td>
</tr>
<tr>
<td>8,000,000</td>
<td>170</td>
</tr>
<tr>
<td>6,000,000</td>
<td>180</td>
</tr>
<tr>
<td>4,000,000</td>
<td>190</td>
</tr>
<tr>
<td>2,000,000</td>
<td>200</td>
</tr>
<tr>
<td><strong>1,644,444</strong></td>
<td><strong>201.78</strong></td>
</tr>
</tbody>
</table>

increase of office workers for example). The effects are predictable and now, can be measured across the four panels (see Exhibit 7).

With the same level of demand, the cap rate can then be modified (rotation of the valuation line) to affect the volume of construction. Finally, the construction function
can be shifted (an increase in construction costs) and the supply conditions will then be changed.

The dynamization of the model may require a fair amount of time and many issues can again be raised about the sensibility of the different parameters and the reality of the adjustments on local markets. One of the difficulties of this exercise is not to get the students too involved in the Excel manipulations and to bring them back to some realistic perceptions of the market adjustments. Unfortunately, this is also a major problem for most academics.

Excel Simulations and Curve Manipulations. Initially, each panel is treated separately in order to facilitate basic manipulation of the curves. The treatment of the Demand line is illustrated in Exhibit 8. From the web page, the students are linked directly to the Excel workbook where, from one quadrant to the next, they can manipulate the static textbook example and then build their own local case. In the next step, they try to shift the demand curve and thus reexamine the new rent level. The other quadrants are not displayed but use the same routine.

The last step would be to go back to the simultaneous equation Excel construction. Only the local example is provided but of course, students should normally start by replicating the textbook example (see Exhibit 9).

Conclusion

As the proof is in the pudding, this model needs to be experimented with. Clearly, this article cannot mimic the full clicking and linking potential of this pedagogical montage, but the idea is sufficiently basic not to require more illustrations. The reader is invited to explore the website that should be active and accessible at least until the end of 2000. The exercise is quite complete and covers many areas of reflection, discussion and provides basic fact finding opportunities for students.

Depending on their previous Excel skills, this exercise could also turn into a major challenge for students. They have to use a large number of basic spreadsheet manipulations and be able to work out the results of simultaneous models.

In a first year course in property economics, only one session is devoted to the presentation of this instrument (two hours of seminar and one hour of lab work). This is far too short to provide all the benefits of the therapy. Thus, this first round should be used as an appetizer and more time could be devoted later in students progression (second or third year) when they have a better grounding in property finance, valuation and construction economics.

References


