Warning: Some Transaction Prices can be Detrimental to your House Price Index

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Abstract

There is a broad consensus in international statistical organizations such as Eurostat, the European Central Bank, and the International Monetary Fund that price indices should be constructed using transaction data. However, transaction data often lag behind actual market developments in the housing market for new-built properties as prices are typically set months or years before transactions are finalized. We find that for two large Polish cities (Warsaw and Poznan), house price indices (HPIs) for existing properties lead indices for new builds by, on average, eight quarters. In Poland and other countries with large markets for new-builds, this lag can dramatically distort National HPIs. The lag also affects the European Union's flagship measure of inflation, the Harmonized Index of Consumer Prices (HICP). This is because the HICP includes owner-occupied housing (on an experimental basis) using exclusively transaction data for new-built properties. We illustrate here that the timeliness issue in the price index for new-built properties disappears when preliminary agreements are used instead of transactions in the compilation of the index.
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1 Introduction

House price indices (HPIs) have multiple purposes; they inform the public, banks, financial markets, and government regulators of developments in the housing market and are often inputs into the overall measure of inflation – a consumer price index (CPI) – used by central banks to set monetary policy. Therefore, accurate measurement of the timing of peaks and troughs is essential for effective macroprudential supervision and monetary policy.

We show here how the prevailing consensus regarding the construction of HPIs can lead to significant time lags that undermine the timeliness, coherence, and usefulness of both the index itself and consumer price indices. The problem relates to the use of transaction prices. Transaction prices – the prices registered when transferring ownership between seller and buyer – have long been considered the gold standard for computing price indices. In particular, Article 3(3) of European Union (EU) Regulation No 2016/792 states that only monetary transactions can be used in the Harmonized Index of Consumer Prices (HICP) in Europe (European Commission, 2018).[1]

In a housing context, the need for transaction prices is stressed in the Eurostat Handbook on Residential Property Price Indices (Eurostat, 2013), Eurostat's Detailed Technical Manual on Owner-Occupied Housing for Harmonised Index of Consumer Prices (Eurostat, 2017), and the International Monetary Fund's compilers' guide (International Monetary Fund, 2020). All these publications recommend transaction prices to the alternatives – appraisals, surveys, and list prices. Appraisal indices tend to be too smooth and backward-looking (Cole et al., 1986; Geltner et al., 2003; Diewert and Shimizu, 2017; Silver, 2016), which is a particular concern for monetary policy and macroprudential supervision. Survey data likewise tend to be backward-looking and suffer from participation bias as not all sampled households/firms are equally likely to respond. Finally, list prices are typically higher than transaction prices, subject to revision over time, and indeed some listed properties are later withdrawn from the market without selling (Shimizu et al., 2016; Anenberg and Laufer, 2017; Lyons, 2019; Kolbe et al., 2021).

[1]The HICP is the flagship consumer price index (CPI) in the EU used by the European Central Bank (ECB) for price stability purposes and for assessing whether countries are ready to join the Euro area. It is jointly compiled by Eurostat (the statistical institute of the European Union) and national statistical institutes of the EU member states following a harmonized statistical methodology.

Transaction-based indices, however have a problem with timeliness. Part of the problem is that it takes time for transactions to be recorded and made available to Land Registries. This problem is well-known and has been extensively discussed in the literature (Shimizu et al., 2016).

Here we focus on a second reason which causes transaction-based indices to lack timeliness: the inclusion of stale contracts for new-built properties into the index. In this regard, we first need to draw attention to the difference between two sub-categories in residential housing markets: The market for newly-built properties (also called the "primary market") and the market for existing properties (sometimes referred to as the "secondary market"). The timeliness problem lies in the market for new-builds, where prices are typically set when the preliminary agreement is signed, which could be at any stage throughout the building process, and thus months or years before the transaction is completed and entered into deed books. How problematic this lag is for the overall transaction price index depends on when, in the construction process, new-built contracts are typically signed and on how large the proportion of the new-built versus the existing property market is.

In our empirical analysis, we focus on the case of Poland, a country in which around half of the residential property transactions consist of new-builds and which has relatively good micro-level data. We are not the first to explore the relationships between the new-build and existing housing market in Poland.[2] In this sense, our study links to the work of Leszczyński and Olszewski (2017), who examine the reaction of each of these Polsish housing markets to changes in economic fundamentals (e.g., unemployment rate, income growth, or real interest rate changes). Our work also relates to Brzezicka et al. (2021), who compare the magnitude of the relative up-and down-movements for new-builds and existing properties for 17 cities in Poland.
However, our focus is different to these studies in that we analyze how the time lag between the signing preliminary agreements for new-builds and their final transactions affects the timeliness (and accuracy) of an overall transaction-based HPI.

Our analysis is made possible by detailed housing data collection combining micro-level data from multiple sources for two major Polish cities (Warsaw and Poznan) over the last

[2]Note that Polish authors generally refer to the market for new-builds "primary housing market" and the market for existing property as "secondary housing market".

two decades. The dataset was collected by one of the authors of this paper (Trojanek). See section 2 for a description of the data.

We measure the time-lag between different sub-indices using variants of the dissimilarity metrics proposed by Diewert (2002, 2009). While these metrics were initially designed to compare vectors of relative prices across countries, we deploy modified versions of them to compare the similarities and dissimilarities between price developments in the two housing market sub-categories. Based on these metrics, we find that the price index for new-builds lags that of existing properties by eight quarters in Warsaw and six quarters in Poznan.

Our study is based on Polish data, and it remains to be seen if similar time lags exist in other countries. If they do, our findings have implications for the European Union's HICP (Harmonized Index of Consumer Prices). The European Commission (EC) recommends that owner-occupied housing (OOH) should be included in the HICP using a transaction-based price index – the owner-occupied-housing index (OOHI) – computed only on the properties that are new to the household sector (the vast majority of which will be new-builds) (Eurostat, 2017). The reasoning behind the EC's recommendation regarding the OOHI and a critique of it is provided in Hill et al. (2020). Using a transaction-based index for new-builds creates two problems: First, some smaller countries find it difficult to generate a reliable OOHI due to the low numbers of quarterly transactions.[3] Second, the OOHI will measure market development with a significant lag if the lags we measure for the Polish market are also observed in other countries of the European Union.

So far, OOH is only being included on an experimental basis in the HICP, mainly due to concerns over the timeliness of the index arising from delays in obtaining the necessary transactions data from notarial authorities in member countries (European Commission, 2018). However, our analysis demonstrates a bigger timeliness problem with the OOHI arising from the long gaps between preliminary agreements and final transactions for new-builds. Given that OOH would have an expenditure weight in the HICP of about 9 percent (Eiglsperger and Goldhammer, 2018), its inclusion could seriously undermine the timeliness of the HICP, supposing the 8-quarter time lag observed for Warsaw exists elsewhere in Europe. When combined with a 9 percent weight for OOH in the HICP, the implication

[3] A further issue here is that self-built properties, which are not transacted in the market, also fall outside the scope of the OOHI.

is that the inclusion of OOH would cause a 2.2-month lag (24×0.09) in the HICP. This lag occurs over and above any lags arising from the delays in recording and transmitting transaction prices to national Land Registries.

A potential solution to the timeliness problem with respect to new-built properties – whether in an overall HPI or an OOHI – would be to include these properties into the price index when the preliminary agreement is first signed, rather than when ownership is transferred on completion of the project. However, as Land Registry offices do not currently collect information on these preliminary agreements, new EU-wide legislation may be needed to address this data gap. It is also debatable whether such a solution would violate the European Commission's requirement that only market transactions be used in official indices. For an HPI, an alternative solution is to focus only on the market for existing properties, although in countries with large markets for new properties, this would imply ignoring a significant part of the overall housing market.

The remainder of this paper is structured as follows: Section 2 describes our dataset. In section 3, we develop the methods used in the empirical analysis and present our results. We explore the implications of our research in section 4 and conclude in section 5.

2 Data

After the massive restructuring following the political transformation in 1989, Poland today has a high share of owner-occupiers. Eighty-five percent of the population live in self-owned properties, which puts Poland into the group of member states with the highest owner-occupier share within the European Union (Eurostat, 2020).

While the ownership structure changed very quickly after the fall of communism, the change of physical building structure is an ongoing process. Driven by strong economic growth – and the need for updating the communist-era housing stock – the Polish building industry brings a large number of new residential housing (particularly apartments) on the market each year. As a result, sales for new residential properties account for around 50 percent of residential housing transactions in larger Polish cities per year (more than 30 percent in Poland).[4] On the other hand, while the Ministry of Justice data counts all property transactions, it is not always clear under which category they fall.

This paper concentrates on two cities: Warsaw, the capital and – with 1.794 million inhabitants – also the largest city in Poland, and Poznan, Poland's fifth-largest city with 0.535 million inhabitants. We restrict our analysis to apartments as they account for the vast majority of residential transactions in Polish cities.[5] Table 1 illustrates the differences in price levels between the two cities.

We collected time series of micro-level data for both cities. Collecting such data in Poland is difficult, as the quality of transaction data differs substantially between different regions and across different ownership structures. In particular, access to transaction data differs for properties with outright ownership rights (around 75 percent of apartment transactions) versus properties with cooperative ownership rights (around 25 percent of apartment transactions). Multiple IT systems and 380 different data collection units are involved in registering the outright ownership transaction, which – so far – are not combined into one official database in the Property Prices Register (PPR). Finding transaction prices of apartments with cooperative ownership rights is even more difficult. The Polish legal system does not count these transactions as real estate transactions, and they are not recorded in the PPR. Obtaining information on these transactions is very time- and cost-intensive, as they are stored in around 3600 separate cooperatives in Poland. For more information on the data situation in the Polish real estate market, see (Trojanek, 2018, 2021).

To increase the information content for each transaction, we include multiple data sources. In particular, we use the following data: The transaction data for Warsaw come from the *Property Price Register* in Warsaw. It generally contains the following information: accurate location, the transaction date, transaction price, the size of an apartment (in m^2), the story in which the apartment is located, the number and area of any auxiliary premises (e.g., a garage/parking spot in an indoor car park or the cellar/residents' lockup),and whether

[4]Precise information on the number of transactions on the Polish residential market is not available but can be estimated based on two sources: a survey by Statistics Poland and information from the Ministry of Justice on the number of notarial deeds concluded (which includes all types of properties). Both of these data sources have some limitations. Statistic Poland estimates are based on data from the Property Price Register, which does not include transactions of cooperatively owned properties. Also, only about 80 percent of real estate transactions are recorded in the Property Price Register.

[5]According to the 2011 *National Census of Population and Housing* (https://stat.gov.pl/en/national-census/), apartments account for 80 percent of dwellings in Polish cities. This share is still higher in larger cities, such as Poznan and Warsaw.

it is newly-built. The dataset covers the period 2006Q2 to 2019Q4. The yearly number of unique transactions ranges from 5 960 and 27 360 observations. The number of properties entered into Warsaw's Property Price Register has increased over time due to an increased effort by the authorities.

The transaction data for Poznan comes from the Property Price Register, notarial deeds, and information gathered from housing cooperatives. The Poznan dataset covers the period 2004Q1 to 2019Q4.

The Property Price Register in Warsaw provided the information on preliminary contacts. Preliminary contracts for purchasing an apartment are often signed at the beginning of the construction process, which implies that the transaction price is often set many months before the final transaction occurs (and is registered). The preliminary contract date was available for 61 868 new-built property transactions. The average number of days between the preliminary agreement and final transactions was around 530 days.

We linked the cadastre data to both the transaction and preliminary-agreement datasets, which allowed us to gain additional information on new-built properties, such as the number of stories or the age of the building.[6] For some existing properties in our dataset, no entries in the cadastre dataset existed. In these cases, we estimated the building height and building age via the "street view application" on maps.google.com. The generation of the dataset is described in more detail in (Trojanek and Gluszak, 2018).

Once the transaction dataset was established, we treated the raw data as follows:

1. We excluded all non-market transactions (e.g., debt collector sales or transactions between family members) as well as apartment sales within buildings with less than four units. We further excluded purchases of multiple apartment units within one building by one buyer as these sales might be transacted at non-market prices.

2. We geo-coded the address of each apartment and computed distances to various amenities (e.g., subway stations, schools, and urban green space), which we included as extra variables for each apartment.

[6] Even though these cadastre data are available in electronic form, this step proved to be difficult due to a lack of uniform standards within the cadastre system. It proved impossible to directly link the datasets, so one of the authors collected each property's cadastre information by hand and merged it with our dataset.

3. To remove outliers in the dataset, we estimated hedonic models of log price separately for each market each year, taking into account the features indicated in Table 2. After that, we removed observations in which the absolute value of studentized residuals is more than 3.[7]

Table 1 provides the summary statistics for our dataset before and after cleaning, while Table 2 lists the available variables.

Table 1: Dataset before and after cleaning

	Primary Market		Secondary Market		Total	
Warsaw						
	Raw	After cleaning	Raw	After cleaning	Raw	After cleaning
Mean price/m^2	7,677.18	7,666.21	7,899.54	8,117.57	7,807.67	7,925.32
Std price/m^2	2,417.10	1,993.12	2,956.16	2,211.27	2,748.48	2,132.80
Observations	91,718	86,877	129,282	117,090	221,000	203,967
Poznan						
Mean price/m^2	5,531.15	5,747.02	4,680.97	4,689.56	5,050.66	5,126.15
Std price/m^2	1,800.39	1,536.41	1,837.24	1,714.78	1,869.43	1,723.97
Observations	41,464	35,957	53,892	51,133	95,356	87,090

Table 1 shows some descriptive statistics of the datasets used in this study.

[7] If the errors are Normal, the studentized residuals follow a t distribution with $(n-k-2)$ degrees of freedom. Any deviation from t coincides with a violation of normality. https://scholar.princeton.edu/sites/default/files/bstewart/files/lecture9handout.pdf provides a discussion on the issue.

Table 2: Variables included in the dataset.

Variable	Description
district	factor variable for each district
area	useable area of the apartment in square meters
construction technology	factor variable, apartment either in building with prefabricated technology or with traditional technology
age	age of building in years
floor level	factor variable, apartment either on ground floor, intermediate floor, or above
height of the building	factor variable, up to fifth storey, from 6 - 17 storey, and above
subway	distance to the nearest subway station in meter
park	distance to the nearest park in meter
school	distance to nearest primary school in meter
storage	factor variable indicating whether apartment has a extra storage possibility
garage	factor variable: either own parking space in garage, outside of the building, or other

The table lists the descriptive variables included in the primary and secondary housing market datasets for Warsaw and Poznan.

3 Methods and Applications

3.1 The Rolling-Time-Dummy (RTD) Hedonic Method

To effectively distinguish between genuine price changes and compositional differences, HPIs are typically computed using hedonic methods.[8] The hedonic approach entails estimating shadow prices on the characteristics of properties (such as floor area, age, and location) to ensure that quality is held fixed when measuring price changes from one period to the next. For example, Eurostat recommends that countries in Europe should compute their official HPIs using hedonic methods (Eurostat, 2017).

For each dataset, we construct price indices using the hedonic rolling-time-dummy (RTD) method. The RTD method, which was first proposed by Shimizu et al. (2003) and further developed by Shimizu et al. (2010) and O'Hanlon (2010), is a relatively simple and flexible hedonic method that has become increasingly popular in recent years.[9] In Europe, the

[8] An alternative is the repeat-sales methods – see for example Melser (2017).

[9] For examples of other hedonic methods for constructing HPIs, see for example Rambaldi and Fletcher (2014) and Waltl (2019).

RTD method is used by Croatia, Cyprus, France, Ireland, and Portugal in their official national HPIs (Hill et al., 2018). Japan is planning to compute its official residential and commercial property price indices using the RTD method (Shimizu and Diewert, 2019). Brunei Darussalam, Peru, and Thailand are using it, and Indonesia is about to start using it (Hill et al., 2021).

The RTD method estimates a hedonic model with a fixed window length (for example, $m + 1$ periods). Supposing that the first period in the window is period t, the first step is to estimate a semi-log hedonic model as follows:

$$\ln p_{\tau n} = \sum_{c=1}^{C} \beta_c z_{\tau cn} + \sum_{s=t+1}^{t+m} \delta_s d_{\tau sn} + \varepsilon_{\tau n}, \tag{1}$$

where n indexes the housing transactions that fall in the rolling window, $p_{\tau n}$ the transaction price of property n in period τ (where $t \leqslant \tau \leqslant t + m$), c indexes the set of available characteristics of the transacted properties, and ε is an identically, independently distributed error term with mean zero. The characteristics of the properties are given by $z_{\tau cn}$, while $d_{\tau sn}$ is a dummy variable that equals 1 when $\tau = s$, and zero otherwise.

Estimating this model using ordinary least squares, the change in the price index from period $t + m - 1$ to period $t + m$ is then calculated as follows:

$$\frac{P_{t+m}}{P_{t+m-1}} = \frac{\exp(\hat{\delta}^t_{t+m})}{\exp(\hat{\delta}^t_{t+m-1})}, \tag{2}$$

where $\hat{\delta}$ denotes the least squares estimate of δ. A superscript t is included on the estimated δ coefficients to indicate that they are obtained from the hedonic model with period t as the base (i.e., $P_t = 1$). As can be seen from (2), the hedonic model with period t as the base is only used to compute the change in house prices from period $t + m - 1$ to period $t + m$. The window is then rolled forward by one period, and the hedonic model is re-estimated. The change in house prices from period $t + m$ to period $t + m + 1$ is now computed as follows:

$$\frac{P_{t+m+1}}{P_{t+m}} = \frac{\exp(\hat{\delta}^{t+1}_{t+m+1})}{\exp(\hat{\delta}^{t+1}_{t+m})}, \tag{3}$$

where now the base period in the hedonic model is period $t + 1$. The price index over multiple periods is computed by chaining these bilateral comparisons together as follows:

$$\frac{P_{t+m+1}}{P_t} = \left[\frac{\exp(\hat{\delta}^{t-m}_{t+1})}{\exp(\hat{\delta}^{t-m}_{t})}\right]\left[\frac{\exp(\hat{\delta}^{t-m+1}_{t+2})}{\exp(\hat{\delta}^{t-m+1}_{t+1})}\right] \times \cdots \times \left[\frac{\exp(\hat{\delta}^{t+1}_{t+m+1})}{\exp(\hat{\delta}^{t+1}_{t+m})}\right]. \tag{4}$$

An important feature of the RTD method is that once a price change P_{t+m}/P_{t+m-1} has been computed, it is never revised. Hence when data for a new period $t+m+1$ becomes available, the price indexes P_t, P_{t+1}, $\ldots$, P_{t+m} are already fixed. The sole objective when re-estimating the hedonic model to include period $t+m+1$ is to compute P_{t+m+1}/P_{t+m}.[10]

We run the RTD model separately for the market of new and existing properties at a quarterly frequency using a six-quarter rolling window.[11] We use the same variables when estimating the hedonic models for the new-built market and the existing market. We also estimate an RTD index based on data on preliminary agreements for new-built properties.

We then compute two aggregate indices – one combines the indices for new-built and existing transactions, the other combines the indices for preliminary agreement and existing properties. We follow the standard approach for combining quarterly indices used by NSIs in Europe by updating the weights once a year (Hill et al., 2018).[12]

To illustrate this case, we change the notation so that t now denotes a year, and q denotes a quarter.

$$P^{agg}_{(t,q),(t,q+1)} = w^p_{t-1}P^p_{(t,q),(t,q+1)} + w^s_{t-1}P^s_{(t,q),(t,q+1)}, \tag{5}$$

where $P^p_{(t,q),(t,q+1)}$ denotes a price index for the market for new-builds comparing quarter $q+1$ in year t with quarter q in the same year, while $P^s_{(t,q),(t,q+1)}$ is the corresponding index for the market for existing properties.

The weights for the new-built and existing property markets are calculated as follows:

$$w^p_{t-1} = \frac{\sum_{n=1}^{Np} p^p_{t-1,n}}{\sum_{n=1}^{Np} p^p_{t-1,n} + \sum_{n=1}^{Ns} p^s_{t-1,n}},$$

[10]More sophisticated versions of the RTD method are considered in Hill et al. (2021).

[11]We chose a six-quarter window, rather than the more common four-quarter window, to stabilize the indices in the first few quarters of the dataset where fewer observations were available.

[12]We observe close to a hundred percent of transactions for both new and existing properties in Poznan. However, in Warsaw, we do not have complete data coverage.

$$w^s_{t-1} = \frac{\sum_{n=1}^{Ns} p^s_{t-1,n}}{\sum_{n=1}^{Np} p^p_{t-1,n} + \sum_{n=1}^{Ns} p^s_{t-1,n}},$$

where $\sum_{n=1}^{Np} p^p_{t-1,n}$ denotes all the new-built properties transacted in year $t-1$, and $\sum_{n=1}^{Ns} p^s_{t-1,n}$ the corresponding existing properties transacted in $t-1$.

The formula in (5) applies when q is the first, second or third quarter of a year. When q is the fourth quarter, the next quarter with which it is being compared is the first quarter in the following year. In this case the aggregate price index is calculated as follows:

$$P^{agg}_{(t,4),(t+1,1)} = w^p_{t-1} P^p_{(t,q),(t,q+1)} + w^s_{t-1} P^s_{(t,q),(t,q+1)}. \tag{6}$$

In other words, the annual weights are updated each year when the first quarter is compared with the second quarter.

3.2 Measuring Lags using Distance Metrics

We use distance metrics to measure the lag (in quarters) between the price index for existing and newly-built apartments. We estimate the lag length that minimizes the two indices' differences separately for each city (Warsaw and Poznan). A distance metric in our context should satisfy the following six axioms:

1. $D(x, \lambda x) = 0$, where λ is a scalar. This axiom implies that if an index is compared with itself or a rebased version of itself, the two indices are interpreted as identical.

2. $D(x, y) = 0$ if and only if $y = \lambda x$. This axiom is a stronger version of (i). It states that two indices are identical only if one is a rebased version of the other.

3. $D(x, y) \geqslant 0$. The metric is strictly non-negative.

4. $D(x, \lambda y) = D(\lambda x, y) = D(x, y)$. This means that the metric is invariant to rebasing one of the indices. For example, if the base year of the index for new-builds is changed from 2010 to 2015, the metric's value is unaffected.

5. $D(x, y) = D(y, x)$. The two indices are treated symmetrically. (Index symmetry)

6. $D(x,y) = D(x^{-1}, y^{-1})$, where x^{-1} refers to a time-reversal of the x index, i.e., where time is run backwards. This axiom is required to ensure that periods with rising index values are treated symmetrically to periods with falling index values (Time symmetry).

Diewert (2002, 2009) proposes three distance metrics for comparing price vectors across countries or periods. As discussed in Steurer et al. (2021), modified versions of these metrics can be used to measure the distance between two indices. Moreover, these modified metrics satisfy all six axioms stated above.[13] The three modified-Diewert metrics can be used to compare indices both in the same time frame and when one index is lagged. Assuming a predictive relationship exists between the two indices, the objective is to find the lag length minimizing their dissimilarity.

Let P_t^p and P_t^s denote the levels of the price indices for the the new-built and existing property markets, respectively, in period t. DM(k) denotes a modified-Diewert metric with the market for new-builds lagging the market for existing properties by k quarters.

Diewert Metric 1 (DM1):

$$DM1(k) = \frac{1}{T-k-1} \sum_{t=1}^{T-k-1} \left[\frac{P_{t+1}^p}{P_t^p} \bigg/ \frac{P_{t+k+1}^s}{P_{t+k}^s} + \frac{P_{t+k+1}^s}{P_{t+k}^s} \bigg/ \frac{P_{t+1}^p}{P_t^p} - 2 \right].$$

Diewert Metric 2 (DM2):

$$DM2(k) = \frac{1}{T-k-1} \sum_{t=1}^{T-k-1} \left[\left(\frac{P_{t+1}^p}{P_t^p} \bigg/ \frac{P_{t+k+1}^s}{P_{t+k}^s} - 1 \right)^2 + \left(\frac{P_{t+k+1}^s}{P_{t+k}^s} \bigg/ \frac{P_{t+1}^p}{P_t^p} - 1 \right)^2 \right].$$

Diewert Metric 3 (DM3):

$$DM3(k) = \frac{1}{T-k-1} \sum_{t=1}^{T-k-1} \left[\ln \left(\frac{P_{t+1}^p}{P_t^p} \bigg/ \frac{P_{t+k+1}^s}{P_{t+k}^s} \right) \right]^2.$$

Diewert (2009) shows that these three metrics approximate each other to the second order.

Three other metrics are 1-PCC, where PCC is the Pearson Correlation Coefficient in log form, and the Hellinger and Euclidean distances.

[13] A more detailed discussion of related metrics can be found in Steurer et al. (2021).

Pearson Correlation Coefficient in Log Form (PCC):

$$PCC(k) = \frac{\sum_{t=1}^{T-k-1} \ln\left(\frac{P_t^p}{\bar{P}_G^p}\right) \ln\left(\frac{P_{t+k}^s}{\bar{P}_G^s}\right)}{\sqrt{\sum_{t=1}^{T-k-1} \left[\ln\left(\frac{P_t^p}{\bar{P}_G^p}\right)\right]^2 \sum_{t=1}^{T-k-1} \left[\ln\left(\frac{P_{t+k}^s}{\bar{P}_G^s}\right)\right]^2}},$$

where $\bar{P}_G^p$ and $\bar{P}_G^s$ denote the geometric mean of the new-built and existing property price indices included in the PCC calculation.

$$\bar{P}_G^p = \left(\prod_{t=1}^{T-k-1} P_t^p\right)^{1/(T-k-1)}, \quad \bar{P}_G^s = \left(\prod_{t=1}^{T-k-1} P_{t+k}^s\right)^{1/(T-k-1)}.$$

Hellinger Distance (HD):

$$HD(k) = \frac{1}{\sqrt{2}} \sqrt{\sum_{t=1}^{T-k-1} \left(\sqrt{\frac{P_{t+1}^p}{P_t^p}} - \sqrt{\frac{P_{t+k+1}^s}{P_{t+k}^s}}\right)^2}$$

Euclidean Distance (ED):

$$ED(k) = \sqrt{\sum_{t=1}^{T-k-1} \left(\frac{P_{t+1}^p}{P_t^p} - \frac{P_{t+k+1}^s}{P_{t+k}^s}\right)^2}$$

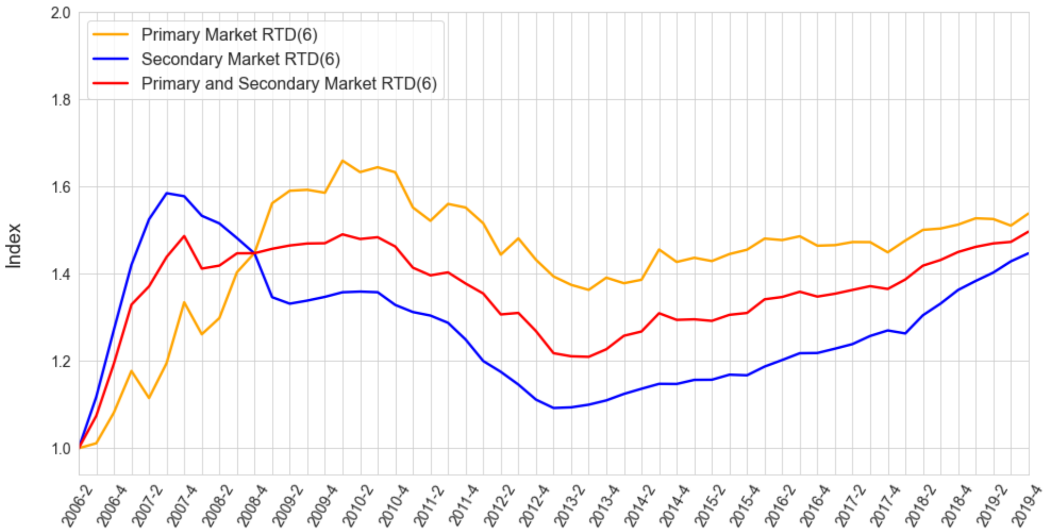
The metric, 1-PCC, satisfies all the axioms except (ii). For example, if we compare the two index series $\{3, 9, 1, 3\}$ and $\{4, 8, 2, 4\}$, we obtain a value of PCC=1, which implies that 1-PCC=0, and yet it is clear that the second index is not a rescaled version of the first. Both the Hellinger and Euclidean distance metrics violate axiom (vi). In other words, they do not treat rising and falling indices symmetrically. However, if the Euclidean distance defined on the price relatives is rewritten in log form, we obtain a metric closely related to DM3 that does satisfy all six axioms.

3.3 Results

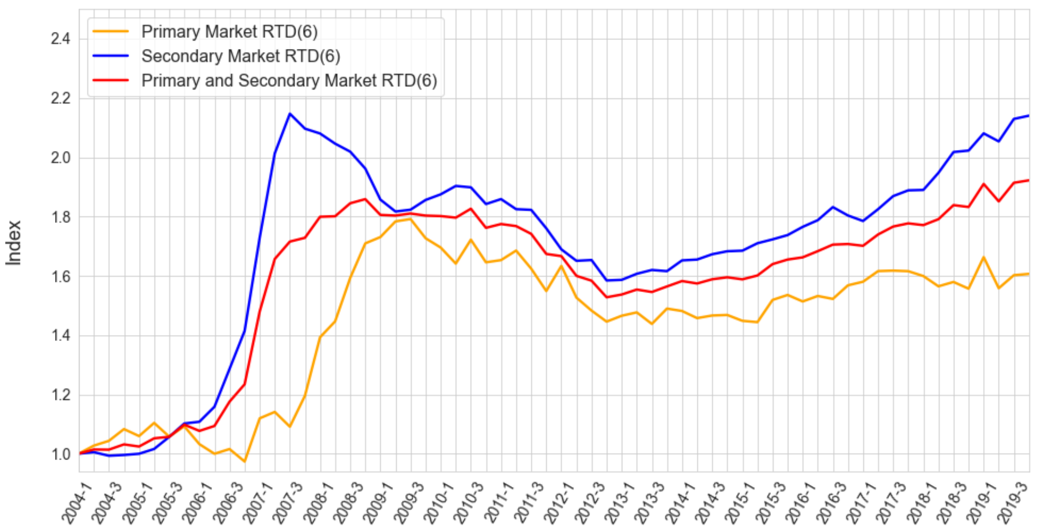
The new-built and existing property price indices for Warsaw and Poznan graphed in Figure 1 are constructed using the RTD hedonic method (subsection 3.1). Also shown are the aggregate indices obtained by combining the indices using the weights in (5) and (6). Given that we have only partial coverage of transactions in the new-build market in

Warsaw, we apply the weights obtained from Poznan – where we have almost complete coverage – to Warsaw. Figure 1 strongly suggests that the price indices for new-builds in both cities lag those for existing properties by multiple quarters. Given that the new-builds price index has a weight of around 40 percent in the aggregated index, this lag significantly distorts the aggregate index.

Figure 1: Real House Price Indices



(a) Warsaw



(b) Poznan

Figure 1 shows the development of new-built and existing property price indices for Warsaw (a) and Poznan (b), as well as a weighted combination of these two indices. Prices were deflated using the Polish CPI (see Figure A1 in Appendix A), and all indices were constructed with the Rolling Time Dummy (RTD) method using a 6-quarter window length.

3.4 Granger Causality Test

We use a Granger causality approach to test whether the price index for existing properties predicts the price index for new-built properties. More specifically, we test the null hypothesis that the index for existing properties cannot predict the index for new-builds. To implement the test, we construct the following two autoregressive models:

$$y_t^p = \alpha_0 + \alpha_1 y_{t-1}^p + \alpha_2 y_{t-2}^p + \cdots + \alpha_m y_{t-m}^p + \varepsilon_t \tag{7}$$

$$y_t^p = \gamma_0 + \gamma_1 y_{t-1}^p + \gamma_2 y_{t-2}^p + \cdots + \gamma_m y_{t-m}^p + \beta_1 y_{t-1}^s + \cdots + \beta_m y_{t-m}^s + \epsilon_t, \tag{8}$$

where y^p and y^s are the corresponding stationary time series (first differences of the log price indices) for the new-built and existing property markets. We determine the number of lags for the new-builds market in (7) by using the autocorrelation function (see Figure B2 and Figure B3). The number of lags for the existing property market in (8) are determined using the Akaike information criterion (see Table B1). We then run an F-test (9) to test whether the price index for existing properties can add additional explanatory power to the model specified in (7).

$$F = \frac{(RSS_1 - RSS_2/(q_2 - q_1))}{(RSS_2/(n - q_2))}, \tag{9}$$

where RSS_1 denotes the residual sum of squares of the restricted model in (7) with the optimal number of lags, and RSS_2 is the corresponding residual sum of squares from the more general model in (8) that includes the secondary market, again with optimal lags. q_1 and q_2 denote the number of parameters in the restricted and more general models, respectively, and n is the number of data points. The test static follows an F distribution with $(q_2 - q_1, n - q_2)$ degrees of freedom.

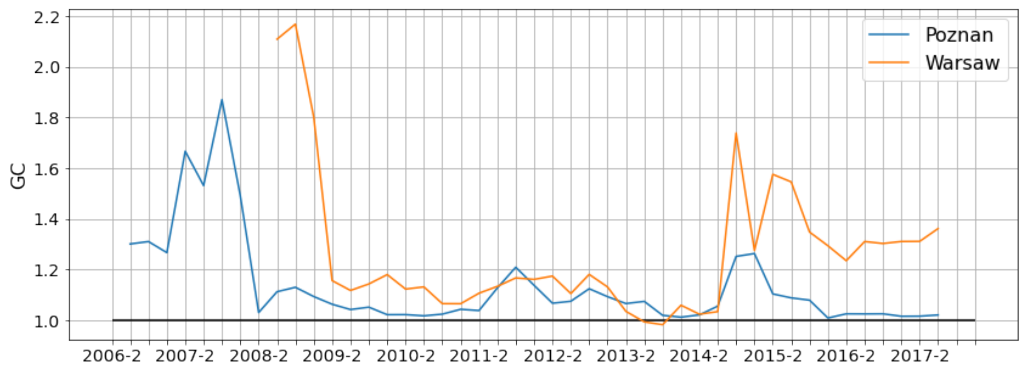
The model results for Warsaw and Poznan are shown in Figure B4 and Figure B7. The result of the F-test statistic (9) for Warsaw (Poznan) is 24.587 (4.4305), yielding a p-value less than 0.001 (0.03965) and hence, the null hypothesis that the price index for existing properties does not Granger-cause the price index for new-builds is rejected for both cities at the 95% significance level.

Another interesting finding when looking at Granger causality can be illustrated by adapting Definition 1 of (Granger, 1969), that states:
"If $\sigma^2(X|U) < \sigma^2(X|U \overline{-} Y)$, we say that Y is causing X".
This definition implies that:

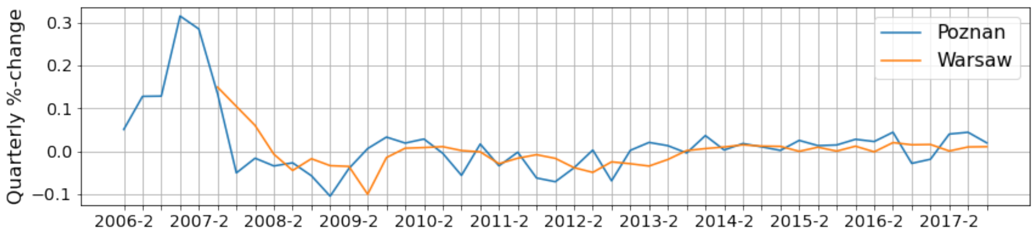
$$GC := \frac{\sigma^2(X|(U \overline{-} Y)}{\sigma^2(X|U)}, \tag{10}$$

where X is the corresponding vector of y_t^p in (7) and (8). U represents the right hand side of (8), and correspondingly U-Y are the right hand side of (7). Figure 2 follows this value over time.[14]

Figure 2: Granger Causality measures (GC) for Warsaw and Poznan



(a) Granger Causality (GC)



(b) Percentage quarterly change of secondary price indices

Figure 2 (a) depicts 16-quarter rolling windows of Equation 10 for Warsaw and Poznan. For values greater than 1 (see solid line above), the price index for existing properties adds explanatory power to the price index for new-builds. Figure 2 (b) shows the corresponding changes in the price indices for existing properties.

In Figure 2a, a value above 1 (indicated by the solid line) indicates that lagged differences from the existing property market improve predictions for the new-builds market. // To put these values in perspective, we include Figure 2b which illustrates the behavior of the corresponding price indices for existing properties.

[14] This time-dependent causality measure was first proposed by Geweke (1982). A variant of it was applied in Stokes and Purdon (2017).

3.5 Measuring the Time Lag

We use the distance metrics described in subsection 3.2 to measure how many quarters the index for new-builds lags that of existing properties. The results for Warsaw are shown in Table 3. Independently of which metric is used, we find an estimated lag of eight quarters. This long time lag still holds when the first and second half of the period is analyzed separately. In other words, the price dynamics of new-build apartments transacted today behave like the price dynamics of existing properties from two years ago. If, however, we substitute preliminary agreement data for new-build properties' transaction data, the time lag between the indices disappears. None of the metrics indicate any lag between the price indices. Table 3 shows the estimated lag results for this case.

Table 3: Different Measures for Lag Estimation between Price Indices for new and existing apartments - Warsaw

		Quarters Lagged												
Time	Metric	0	1	2	3	4	5	6	7	8	9	10	11	12
2006-Q2 –2019-Q4	ED	0.322291	0.301150	0.316026	0.315085	0.286432	0.285711	0.278631	0.225813	**0.207451**	0.232671	0.259395	0.275590	0.269472
	DM1	0.001835	0.001636	0.001843	0.001882	0.001592	0.001589	0.001547	0.001039	**0.000883**	0.001138	0.001454	0.001661	0.001619
	DM2	0.003690	0.003292	0.003716	0.003788	0.003207	0.003206	0.003115	0.002082	**0.001771**	0.002281	0.002918	0.003336	0.003252
	DM3	0.001833	0.001635	0.001841	0.001880	0.001590	0.001587	0.001545	0.001039	**0.000883**	0.001138	0.001453	0.001660	0.001618
	HD	0.112542	0.105226	0.110518	0.110400	0.100446	0.099760	0.097350	0.078936	**0.072262**	0.081085	0.090498	0.095891	0.093667
	1-PCC	0.893741	0.815482	0.746859	0.661109	0.551372	0.465249	0.382675	0.297460	**0.286216**	0.368467	0.497925	0.649733	0.747065
2006-Q2 –2012-Q4	ED	0.310755	0.286076	0.304319	0.298690	0.268366	0.264212	0.256014	0.188852	**0.174555**	0.202955	0.227166	0.245923	0.237144
	DM1	0.003535	0.003121	0.003696	0.003741	0.003167	0.003150	0.003110	0.001764	**0.001561**	0.002253	0.003017	0.003731	0.003686
	DM2	0.007113	0.006284	0.007456	0.007534	0.006386	0.006363	0.006269	0.003535	**0.003131**	0.004516	0.006061	0.007501	0.007412
	DM3	0.003531	0.003118	0.003691	0.003737	0.003163	0.003145	0.003106	0.001764	**0.001561**	0.002252	0.003015	0.003728	0.003683
	HD	0.108449	0.099880	0.106367	0.104587	0.094039	0.092088	0.089267	0.065695	**0.060444**	0.070419	0.078931	0.085225	0.082013
	1-PCC	0.911577	0.815349	0.749268	0.657993	0.511637	0.436830	0.334184	0.147936	**0.108369**	0.212241	0.417553	0.726680	0.856669
2013-Q1 –2019-Q4	ED	0.084939	0.093952	0.083135	0.089452	0.083144	0.089321	0.053900	0.057819	**0.042888**	0.052897	0.050182	0.052348	0.051840
	DM1	0.000262	0.000333	0.000271	0.000327	0.000294	0.000355	0.000138	0.000166	**0.000097**	0.000155	0.000147	0.000170	0.000178
	DM2	0.000525	0.000667	0.000543	0.000655	0.000588	0.000711	0.000276	0.000333	**0.000193**	0.000310	0.000295	0.000341	0.000356
	DM3	0.000262	0.000333	0.000271	0.000327	0.000294	0.000355	0.000138	0.000166	**0.000097**	0.000155	0.000147	0.000170	0.000178
	HD	0.029887	0.033066	0.029251	0.031477	0.029226	0.031411	0.019036	0.020420	**0.015151**	0.018685	0.017717	0.018482	0.018301
	1-PCC	0.912385	0.816347	0.749926	0.658314	0.511723	0.435682	0.331951	0.147915	**0.108347**	0.212383	0.417698	0.726509	0.856363
		Preliminary agreement												
2006-Q2 –2019-Q4	ED	**0.184759**	0.235226	0.245887	0.277539	0.299050	0.314288	0.305036	0.325515	0.349900	0.348919	0.299385	0.275075	0.270597
	DM1	**0.000627**	0.001032	0.001126	0.001458	0.001726	0.001964	0.001893	0.002182	0.002567	0.002617	0.001930	0.001652	0.001627
	DM2	**0.001257**	0.002071	0.002262	0.002936	0.003483	0.003955	0.003811	0.004416	0.005210	0.005304	0.003890	0.003330	0.003277
	DM3	**0.000627**	0.001032	0.001126	0.001456	0.001724	0.001962	0.001890	0.002178	0.002561	0.002612	0.001927	0.001650	0.001625
	HD	**0.065160**	0.082872	0.086185	0.097181	0.104701	0.110308	0.107120	0.114048	0.122472	0.122226	0.104354	0.095659	0.093976
	1-PCC	**0.030419**	0.081580	0.200781	0.335271	0.476133	0.586087	0.679863	0.822648	0.917967	0.952438	0.936023	0.981939	1.069651

The top three sub-sections of Table 3 illustrate the results of various distance measures between the price indices for new and existing apartments in Warsaw for the entire dataset and separately for 2006 to 2012 and 2013 to 2019. All measures indicate that an 8-quarter lag minimizes the difference between the two price index series. The last section of Table 3 indicates that a lag of 0 quarters minimizes the difference between the price index for existing apartments and the new-built apartment price index compiled with the dates of the preliminary agreement.
Note, ED stands for Euclidean distance, DM1, DM2, and DM3 stand for Diewert measure 1, 2, and 3, HD stands for Hellinger distance, and 1-PCC stands for 1 - Pearson Correlation Coefficient.

Equivalent results for Poznan are presented in Table 4. Again, the metrics are almost in complete agreement that the new-build index lags behind existing apartments by six quarters. When splitting the dataset into two periods, the first half indicates a six-quarter while the second half has a five-quarter lag. In this last case, two of the metrics disagree with each other. The DM metrics, however, are always in complete agreement.

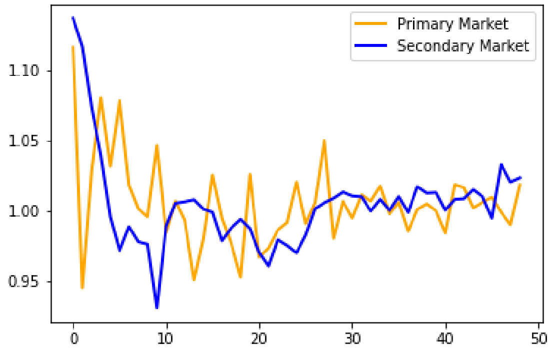
Table 4: Different Measures for Lag Estimation between Price Indices for new-built and existing apartments - Poznan

		Quarters Lagged												
Time	Metric	0	1	2	3	4	5	6	7	8	9	10	11	12
2004-Q1 –2019-Q4	ED	0.456320	0.501780	0.437231	0.381388	0.375772	0.361538	**0.324406**	0.396296	0.426765	0.421899	0.465360	0.491123	0.461415
	DM1	0.003092	0.003737	0.002884	0.002276	0.002255	0.002075	**0.001698**	0.002541	0.002982	0.002956	0.003668	0.004180	0.003764
	DM2	0.006220	0.007549	0.005838	0.004571	0.004533	0.004170	**0.003405**	0.005107	0.006012	0.005953	0.007408	0.008463	0.007621
	DM3	0.003089	0.003731	0.002878	0.002274	0.002253	0.002074	**0.001697**	0.002539	0.002978	0.002953	0.003662	0.004172	0.003757
	HD	0.158550	0.173574	0.151215	0.132609	0.130791	0.125066	**0.112188**	0.136556	0.146826	0.145008	0.159981	0.168997	0.158793
	1-PCC	0.241634	0.193087	0.136907	0.086207	0.048586	**0.030465**	0.033312	0.068995	0.125948	0.202168	0.301799	0.420446	0.558519
2004-Q1 –2012-Q4	ED	0.420380	0.458756	0.406837	0.333443	0.321598	0.306302	**0.279027**	0.348294	0.377786	0.381501	0.423856	0.444211	0.412754
	DM1	0.005271	0.006352	0.005181	0.003649	0.003524	0.003205	**0.002774**	0.004428	0.005408	0.005775	0.007487	0.008662	0.007847
	DM2	0.010610	0.012854	0.010508	0.007333	0.007091	0.006449	**0.005566**	0.008907	0.010921	0.011644	0.015152	0.017576	0.015930
	DM3	0.005265	0.006340	0.005169	0.003646	0.003520	0.003202	**0.002772**	0.004423	0.005399	0.005767	0.007472	0.008641	0.007828
	HD	0.145627	0.158042	0.140216	0.115313	0.111257	0.104996	**0.095720**	0.119011	0.128915	0.130246	0.144797	0.151859	0.140991
	1-PCC	0.271137	0.213816	0.150065	0.089720	0.044338	0.020508	**0.018431**	0.047339	0.097537	0.164895	0.249426	0.345708	0.441762
2013-Q1 –2019-Q4	ED	0.149870	0.181066	0.146282	0.156658	0.172340	**0.137540**	0.138451	0.148472	0.150808	0.134935	0.125721	0.159013	0.137321
	DM1	0.000725	0.001088	0.000739	0.000875	0.001098	**0.000720**	0.000766	0.000920	0.000985	0.000818	0.000748	0.001264	0.000994
	DM2	0.001451	0.002181	0.001480	0.001755	0.002202	**0.001443**	0.001534	0.001845	0.001975	0.001639	0.001498	0.002536	0.001992
	DM3	0.000725	0.001088	0.000739	0.000875	0.001098	**0.000720**	0.000766	0.000920	0.000985	0.000818	0.000748	0.001263	0.000994
	HD	0.052985	0.063939	0.051737	0.055355	0.060890	0.048497	0.048926	0.052508	0.053254	0.047555	**0.044377**	0.056203	0.048562
	1-PCC	0.243511	0.188139	**0.172815**	0.191483	0.198553	0.177997	0.188387	0.220142	0.277500	0.313184	0.366894	0.503478	0.564818

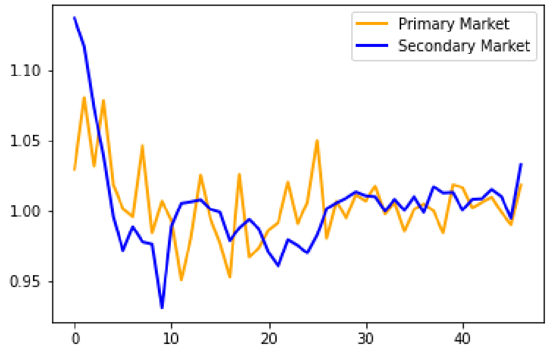
The top three sub-sections of Table 3 illustrate the results of various distance measures between indices for new-built and existing apartments for Poznan. Results are shown for the entire period and separately for 2006 to 2012 and 2013 to 2019. A six-quarter lag minimizes the difference between the two price index series overall and in the sub-sample between 2006 and 2012. For data between 2013 and 2019, four measures indicate that a five quarter lag minimizes the difference between the two series.
Note: ED stands for Euclidean distance, DM1, DM2, and DM3 stand for Diewert measure 1, 2, and 3, HD stands for Hellinger distance, and 1-PCC stands for 1-Pearson Correlation Coefficient.

Figure 3 shows the index for new-built apartments in Warsaw against lagged versions of the index for existing apartments. The graphs visually confirm the findings from Table 3. The two indices are best aligned when the index for existing apartments is lagged by eight quarters. Similarly, Figure 4, depicts the index for new-builds in Poznan and differently lagged versions of the index for existing apartments. Again the graphs visually confirm the findings from Table 4, that the indices are best aligned when the index for existing apartments is lagged by six quarters.

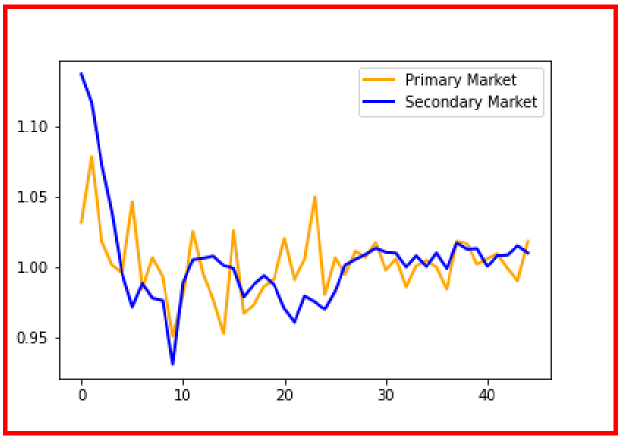
Figure 3: Stationary Price Indices for Warsaw with different lags



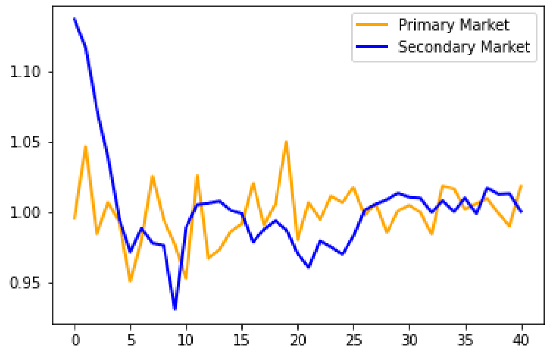
(a) 2-Quarter Lag



(b) 6-Quarter Lag



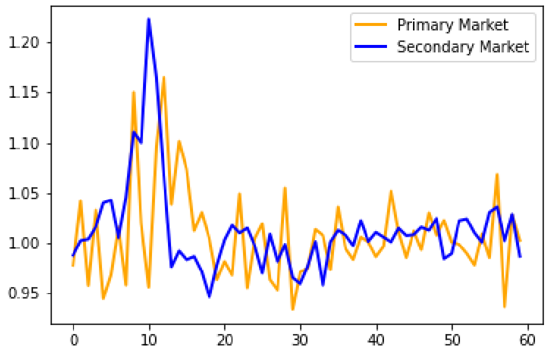
(c) 8-Quarter Lag



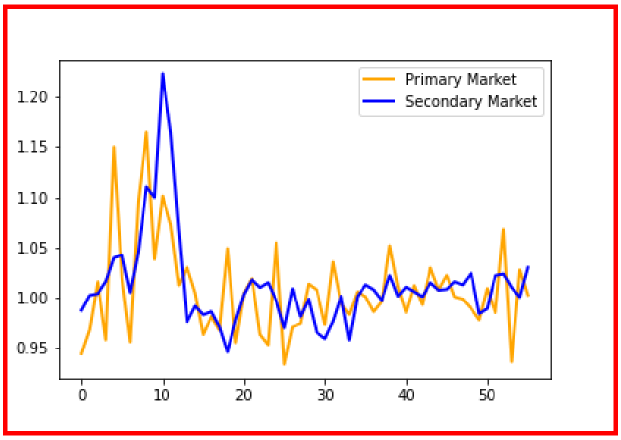
(d) 12-Quarter Lag

The above figures illustrate the first-difference of the price indices for new and existing apartments in Warsaw. The price index for new apartments is lagged by either 2 (a), 6 (b), 8 (c), or 12 (d) quarters. We find the best overlap with a 8 quarter lag.

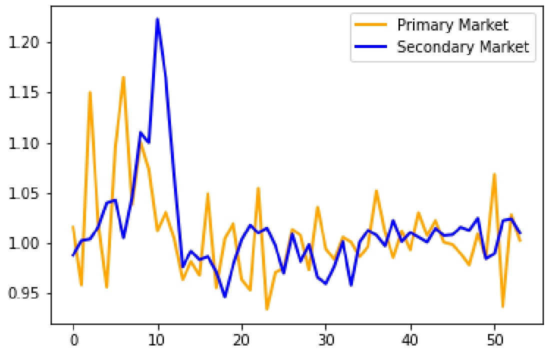
Figure 4: Stationary Price Indices for Poznan with Different Lags



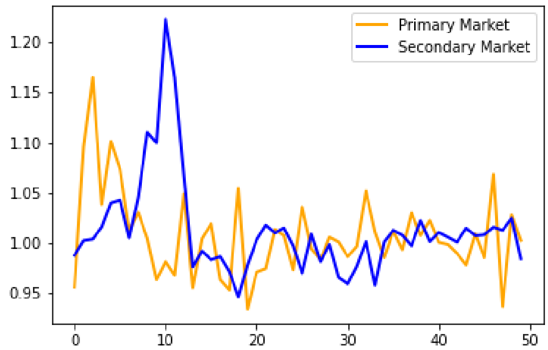
(a) Secondary Market Lagged by 2 Quarters



(b) Secondary Market Lagged by 6 Quarters



(c) Secondary Market Lagged by 8 Quarters

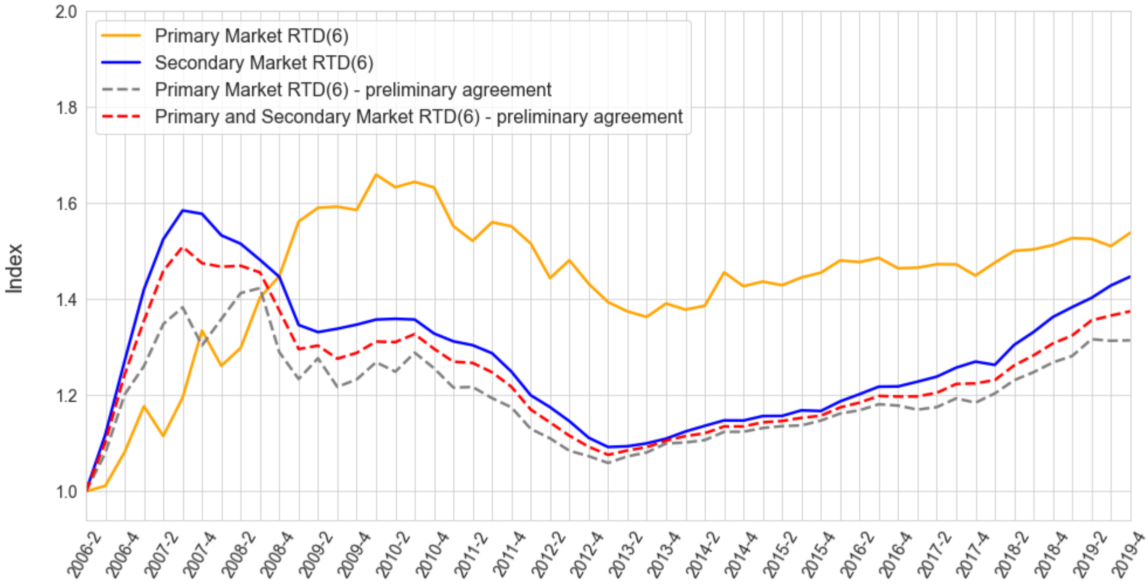


(d) Secondary Market Lagged by 12 Quarters

The above figures illustrate the first-difference of price indices for new and existing apartments in Poznan, with the index for new-builds lagged by 2 (a), 6 (b), 8 (c), and 12 (d) quarters. The best overlap occurs with a 6 quarter lag.

A comparison of indices compiled from preliminary agreement data and transactions for existing apartments is shown in Figure 5. An aggregate index formed by combining the preliminary agreement and secondary indices does not seem to lag the secondary index at all, which confirms our results from Table 3.

Figure 5: Real House Price Indices including Preliminary Agreement (dashed) for Warsaw



All indices are constructed with the Rolling Time Dummy (RTD) method using a 6-quarter window length.

The figure shows the development of apartment price indices compiled from data for new, existing, or preliminary agreements for Warsaw. The combined index for apartment prices is built by using preliminary agreement dates instead of transaction dates for new-builds.

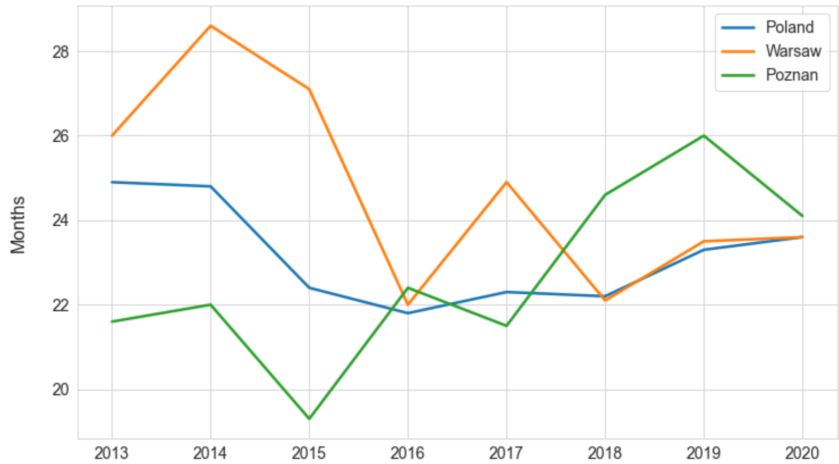
4 The Time Lag in the Index for New-Builds and its Implications

4.1 Explaining the Lag

We consider each of these in turn. The average building times for Warsaw and Poznan are shown in Figure 6, starting from 2013. For Warsaw, we find that the apartment building process took about 25 months, while in Poznan, it took around 23 months. The two-month time difference in average building time could potentially explain the two months longer time lag we find for Warsaw compared to Poznan. The result for Warsaw fits precisely with the eight-quarter time lag identified in Table 3. The 23 month building time in Poznan is slightly longer than the six-quarter lag identified in Table 4.

At which stage throughout the construction process preliminary agreements are signed will

Figure 6: Average Building Time in Months



The figure illustrates the mean time lag between building approval and completion for Poland, Warsaw, and Poznan between 2013 and 2020.

depend partly on the state of the housing market.

If buyers commit sooner during booms than at other times, there should be a cyclical component in the lag-time of the new-built apartment price index. Even though we found that the overall lag time stayed stable over the 23-year study period, we find some indications for cyclical behavior when comparing the peaks of the price indices for new and existing apartments in Figure 1.

The index results tell us that the Warsaw market for existing apartments peaked in 2007Q2, while the market for new-built apartments peaked in 2009Q4. However, buyers of new-built apartments did not continue to agree to increasing prices during a two year period during which prices for existing properties fell, they were already locked into their earlier contracts.

The price agreed by the buyer and seller in the preliminary agreement will be influenced by expectations of how future prices will develop. The more accurately market participants anticipate future price developments, the smaller the lag between the price indices for new and existing properties. We thus suspect that the lag between the two indices will be shorter (and the overlap between price trends stronger) when the housing market is calm and more predictable.

4.2 Implications for National House Price Indices (HPIs) and their users

New-built properties are often bought off the plan with prices agreed on months or years before the transaction. As a result, the prices stated in purchase contracts can be stale at the time of the transaction. For countries in which a significant part of the property market consists of new-built properties, including these stale new-built transaction prices can undermine the timeliness of the HPI. This situation is particularly problematic when using the resulting price index for macroprudential supervision or as input for monetary policy decisions, as the timelines of estimated housing market movements are crucial in this context.

One way to avoid the time lag in the price index for new-builds would be to exclude new-built apartments (at least those from developers) from the HPI, especially for the HPI that is used for macroprudential supervision and monetary policies. The HPI for macro-prudential supervision and monetary policies would then cover only existing properties (and new-builds completed by private households). The drawback of this approach is that this price index does not provide a complete picture of overall housing market developments. Thus, a trade-off exists between market coverage and timeliness. Note, the the relative similarity in price trends between existing and new apartments and the relative share of the new-built apartment market will determine the size of this trade-off. A second way to avoid the time lag in the HPI is to replace transactions for new-builds with preliminary agreements. Our results for Poland show that an index based on preliminary agreements does not show any lag. One problem with this solution is that Land Registries in many countries do not currently collect preliminary agreement prices. Note also that EU regulations stipulate that only *transaction-based* data are allowed for index compilation. Including preliminary agreements (which can still be forfeited by buyers) would thus be problematic for official HPIs.

4.3 Implications for the Harmonized Index of Consumer Prices (HICP) and its users

The European Commission, in its Article 3(3), requires that the HICP is constructed only using data on actual transactions (European Commission, 2018). In a housing context, the approach agreed for including OOH in the HICP – the net acquisitions method – goes further by requiring that the owner-occupied-housing price index (OOHI) should be constructed only using transaction data for new-built properties (Hill et al., 2020). This is the case as the net acquisitions approach aims to treat housing in the HICP like it treats other consumer durables. In the HICP, the transaction of consumer durables is accounted for once, namely when a household purchases the new product. Subsequent (second-hand) transactions between households are not entered into HICP measurements. So, the sale of a newly produced car enters the HICP, while that of a second-hand car does not.

However, real estate is different from other consumer durables. In particular, the time lag between committing to buy a property and when it is finally transacted is generally much longer in property than with cars or refrigerators. As a result, the prices for new-built properties can be stale by the time transactions happen, leading to a price index that shows a lagged price development of the overall housing market.

In the case of Poland, this lag is two years. So far, we do not know how large this lag is in other EU countries.

Given OOH's considerable weight in the HICP (about 9 percent according to Eiglsperger and Goldhammer (2018)), a two-year lag in the OOHI would be highly problematic. Indeed, combining a 24-month lag in the OOHI with a 9 percent expenditure weight in the HICP implies that the inclusion of OOH would cause a lag of about 2.2 months (24×0.09) in the HICP (over and above any lags arising from delay in recording and transmitting transaction prices to national Land Registries). When evaluating the significance of such a delay, it is worth remembering that the HICP is the flagship measure of inflation used by the ECB for setting monetary policy and that there is about a two and a half year time lag until the full impact of monetary policy decisions is felt in the economy (Havranek and Rusnak, 2013). Therefore, the HICP must capture the very latest price trends in the economy. OOH is currently included in the HICP only on an experimental basis. Ironically, a significant reason OOH has not yet been integrated into the official HICP is not because of the time lags associated with newly built properties, but rather because many EU countries cannot supply the housing data quickly enough to meet HICP guidelines. These guidelines state that all data each month must be provided to the ECB not more than 15 days after the end of the month (European Commission, 2018). This strict deadline exists to ensure that the HICP is released quickly based on the most up-to-date data available. However – in the case of Poland at least – the timeliness issue related to the data release is a far smaller problem than the inherent lags in off-the-plan transactions.

How then should the OOHI be constructed? One option is to replace a transaction-based index with an index based on preliminary agreements for apartment purchases.[15] As noted above, our results for Poland show that an index constructed in this way does not lag behind the price development for the market of existing properties. For a practical implementation of this option, authorities would need to collect data on preliminary agreements (at the time they are signed). Still, there remains the question of whether an index that substitutes prices and dates of preliminary agreements for those of final transactions could fall within the rules of Article 3(3). There are, however, two further problems with the OOHI. First, in some smaller EU countries, the number of transactions for new built properties each month is so low that it is problematic to construct a quality-adjusted index.[16] Switching from transaction data to contract agreement data helps with the timeliness of the index but does not increase the number of observations available for index compilation. From the point of index stability, it would thus be better to use an index that includes new and existing properties to measure house price inflation in the HICP.

This plan would produce a more robust OOHI that would also better represent the price development of the overall housing market, even if it is not entirely consistent with the underlying logic of the net acquisitions approach.

[15]Houses are far less often bought "off-the-plan" than apartments.
[16]The HICP is computed monthly.

5 Conclusion

Timeliness is essential for house price indices (HPIs), especially when they are used for macroprudential supervision or as inputs into consumer price indices (CPIs). A distinction can be drawn between two sources of delay, one of which has received much attention in the literature, while the other hardly any. The widely recognized source concerns delays in recording transactions by notaries and transferring and transcribing these transactions by national Land Registries. Because of these delays (and doubts over the feasibility of a monthly OOHI in some countries), owner-occupied housing (OOH) is still excluded from the official harmonized index of consumer prices (HICP) (European Commission, 2018).

In this paper, we highlighted a second and so far under-appreciated source of delay, which arises from the time lag between signing preliminary agreements and final transactions for new-built apartments.

In off-the-plan apartment purchases, prices are often agreed upon years before the final transaction, with the result, that transaction prices are stale by the time they enter the price index. In Poland, where most new-built properties are sold "off-the-plan", this time lag is substantial.
We showed that Warsaw's price index for new-built apartments lags that of existing apartments by eight quarters. For Poznan this lag is slightly lower at six quarters. Delays of this magnitude are problematic. They are particularly problematic for the inclusion of Owner-Occupied Housing (OOH) into the HICP, given that the European Commission's preferred treatment of OOH – the net acquisitions method – requires an HPI that focuses exclusively on the market for new-built properties.

We discussed two potential ways to deal with this time lag in the market for new-built apartments. One possibility is to focus exclusively on the secondary market when constructing a market price index. However, if the price dynamics in the new and existing property market differ, this index can provide a misleading picture of developments for the overall housing market, particularly in countries with large markets for new-built apartments. A second (and maybe more promising) way to improve the timeliness of HPIs (as well as the European Union's HICP) may be to replace data on transactions for new-built apartments with data on preliminary agreements when constructing indices. Our results with Polish data indicate that an index for new-built apartments that is compiled in this way does not lag the price movement of the secondary market. To implement this solution, it is crucial that authorities collect information on preliminary agreements.

This delay is problematic. It is a particular problem for the HICP, given that the European Commission's preferred treatment of OOH – the net acquisitions method – requires a house price index that focuses exclusively on new-built properties. The method already faces problems as some smaller EU countries with low new-build transaction numbers find it hard to compile stable indices at quarterly or even monthly frequency. The time-lag we discussed in this paper adds another problem for including owner-occupied housing (OOH) into the HICP. Note that in contrast to the issue of low transaction numbers, this timeliness can apply equally to countries with large and small new-built housing markets. It depends on when prices for new-built apartments are set compared to their transaction dates.

Outside the HICP structure, there is more flexibility in how price indices are constructed. One solution to the timeliness problem in an HPI would be to focus exclusively on the secondary market. However, this can provide a misleading picture of developments in the overall housing market, particularly in countries with large markets for new apartments.

Our results indicate that a second and probably more promising way to improve the timeliness of HPIs and the HICP may be to replace the transaction-based index for the market for new-built apartments with one computed using data on preliminary agreements. This can then be combined with a transaction based index for existing properties index to improve overall market coverage. In the context of the HICP, this might require a change in approach to the treatment of OOH away from an acquisitions-type method to a user-cost or rental equivalence approach that focuses on the service flow of housing (Hill et al., 2020). Whichever approach is followed, it is crucial that authorities collect information on preliminary agreements.

References

Anenberg, E. and Laufer, S. (2017). A more timely house price index. *Review of Economics and Statistics*, 99(4):722–734.

Cole, R., Guilkey, D., and Miles, M. (1986). Toward an assessment of the reliability of commercial appraisals. *The Appraisal Journal*, 54(3):422–432.

Diewert, W. E. (2002). *Similarity and Dissimilarity Indexes: An Axiomatic Approach.* Discussion Paper 02-10, Department of Economics, University of British Columbia, Vancouver, Canada.

Diewert, W. E. (2009). Durables and owner-occupied housing in a consumer price index. In *Price Index Concepts and Measurement*, pages 445–500. University of Chicago Press.

Diewert, W. E. and Shimizu, C. (2017). Alternative approaches to commercial property price indexes for Tokyo. *Review of Income and Wealth*, 63(3):492–519.

Eiglsperger, M. and Goldhammer, B. (2018). *Consumer price indices, owner-occupied housing and measures of underlying inflation in monetary policy of selected central banks.* Paper prepared for the "Meeting of the Group of Experts on Consumer Price Indices", 7 - 9 May 2018, Geneva, Switzerland. Corrected version: 7 August 2018. https://unece.org/fileadmin/DAM/stats/documents/ece/ces/ge.22/2018/ECB.pdf.

European Commission (2018). *Report from the Commission to the European Parliament and the Council on the suitability of the owner-occupied housing (OOH) price index for integration into the harmonised index of consumer prices (HICP) coverage.* European Commission, Brussels, 29.11.2018 COM(2018) 768 final.

Eurostat (2013). Handbook on residential property price indices. https://ec.europa.eu/eurostat/documents/3859598/5925925/KS-RA-12-022-EN.PDF.

Eurostat (2017). *Detailed Technical Manual on Owner-Occupied Housing for Harmonised Index of Consumer Prices.* Luxembourg: Publications Office of the European Union.

Eurostat (2020). *Housing in Europe, Statistics Visualised, 2020 edition.* Luxembourg: Publications Office of the European Union, Luxembourg.

Geltner, D., MacGregor, B., and Schwann, G. (2003). Appraisal smoothing and price discovery in real estate markets. *Urban Studies*, 40:1047–1064.

Geweke, J. (1982). Measurement of linear dependence and feedback between multiple time series. *Journal of the American Statistical Association*, 77(378):304–313.

Granger, C. W. J. (1969). Investigating causal relations by econometric models and cross-spectral methods. *Econometrica*, 37:424–438.

Havranek, T. and Rusnak, M. (2013). Transmission lags of monetary policy: A meta-analysis. *International Journal of Central Banking*, 9(4):39–75.

Hill, R. J., Scholz, M., Shimizu, C., and Steurer, M. (2018). An evaluation of the methods used by european countries to compute their official house price indexes. *Economie et Statistique*, 500-502:221–238.

Hill, R. J., Scholz, M., Shimizu, C., and Steurer, M. (2021). Rolling-time-dummy house price indexes: Window length, linking and options for dealing with low transaction volume. *Journal of Official Statistics*, forthcoming.

Hill, R. J., Steurer, M., and Waltl, S. (2020). Owner-occupied housing, inflation and monetary policy. *Graz Economics Papers*, 2020-18.

International Monetary Fund (2020). *Residential Property Price Index: Practical Compilation Guide*. Washington DC.

Kolbe, J., Schulz, R., Wersing, M., and Werwatz, A. (2021). Real estate listings and their usefulness for hedonic regressions. *Empirical Economics*, forthcoming.

Lyons, R. C. (2019). Can list prices accurately capture housing price trends? insights from extreme markets conditions. *Finance Research Letters*, 30:228–232.

Melser, D. (2017). Disaggregated property price appreciation: The mixed repeat sales model. *Regional Science and Urban Economics*, 66:108–118.

O'Hanlon, N. (2010). Constructing a national house price index for ireland. *Journal of the Statistical and Social Inquiry Society of Ireland*, 40:167–196.

Rambaldi, A. N. and Fletcher, C. S. (2014). Hedonic imputed property price indexes: the effects of econometric modeling choices. *Review of Income and Wealth*, 60:S423–S448.

Shimizu, C. and Diewert, W. E. (2019). *Residential Property Price Index in Japan: Discussion in Methodology and Data Sources*. Paper presented at the International Conference on Real Estate Statistics, Eurostat, Luxembourg.

Shimizu, C., Nishimura, K. G., and Watanabe, T. (2016). House prices at different stages of the buying/selling process. *Regional Science and Urban Economics*, 59:37–53.

Shimizu, C., Takatsuji, H., and Ono, H. (2003). Conjunct method of deriving a hedonic price index in a secondhand housing market with structural change (in japanese). *Reitaku International Journal of Economic Studies*, 10(2):103–134.

Shimizu, C., Takatsuji, H., Ono, H., and Nishimura, K. G. (2010). Structural and temporal changes in the housing market and hedonic housing price indices. *International Journal of Housing Markets and Analysis*, 3(4):351–368.

Silver, M. (2016). How to better measure hedonic residential property price indexes. *IMF Working Papers*, 2016/213.

Steurer, M., Hill, R. J., and Pfeifer, N. (2021). Metrics for evaluating the performance of machine learning based automated valuation models. *Journal of Property Research*, 38(2):99–129.

Stokes, P. A. and Purdon, P. L. (2017). A study of problems encountered in Granger causality analysis from a neuroscience perspective. *Proceedings of the National Academy of Sciences*, 114(34):E7063–E7072.

Trojanek, R. (2018). *Teoretyczne i metodyczne aspekty wyznaczania indeksów cen na rynku mieszkaniowym*. Poznań University of Economics and Business Press, Poznań. https://wydawnictwo.ue.poznan.pl/en/book.html?isbn=978-83-7417-984-3.

Trojanek, R. (2021). Housing price cycles in poland – the case of 18 provincial capital cities in 2000–2020. *International Journal of Strategic Property Management*, 25(4):332–345. https://doi.org/10.3846/ijspm.2021.14920.

Trojanek, R. and Gluszak, M. (2018). Spatial and time effect of subway on property prices. *Journal of Housing and the Built Environment*, 33:359–384. https://doi.org/10.1007/s10901-017-9569-y.

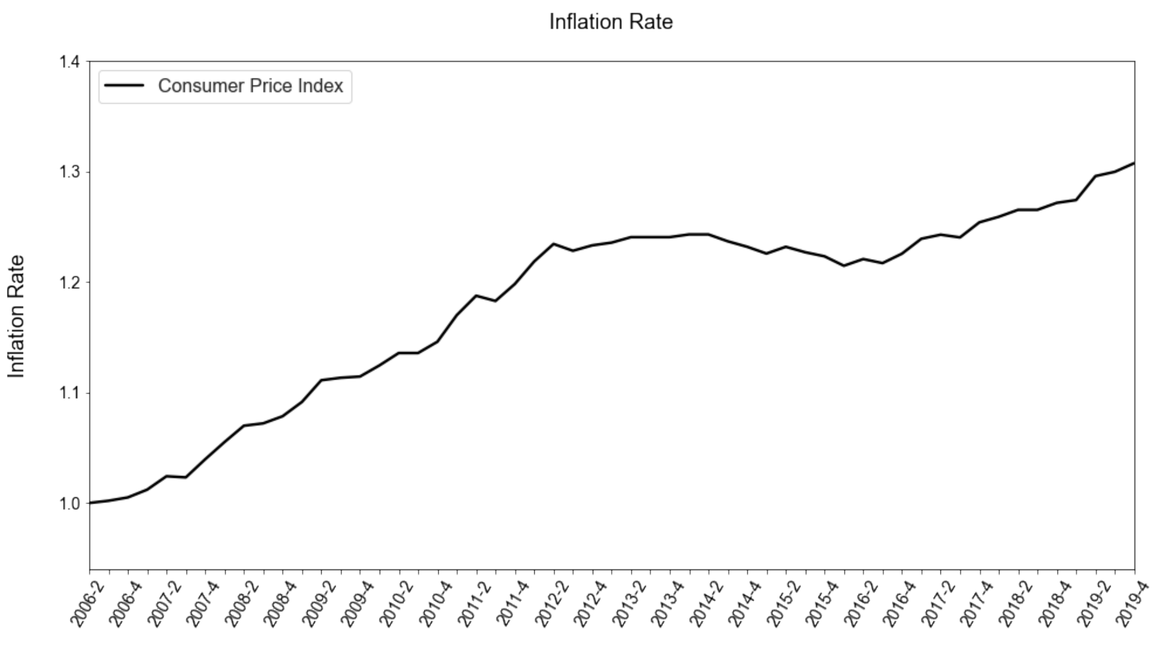
Waltl, S. R. (2019). Variation across price segments and locations: A comprehensive quantile regression analysis of the sydney housing market. *Real Estate Economics*, 47(3):723–756.

Appendix

A Price Indices

A.1 Inflation rate for Poland

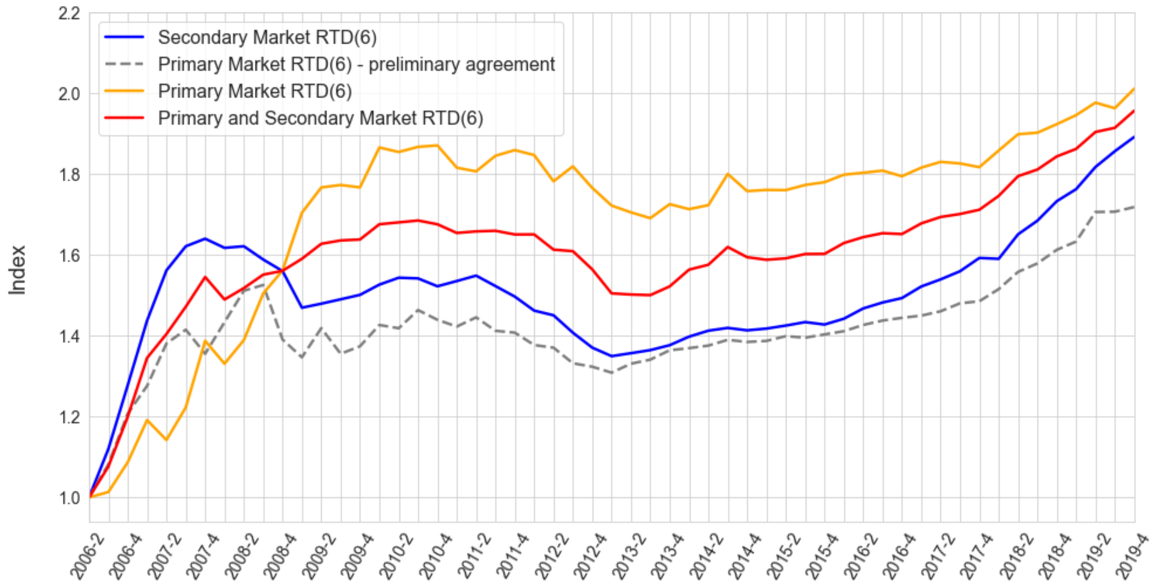
Figure A1: Development of Polish Consumer Price Index



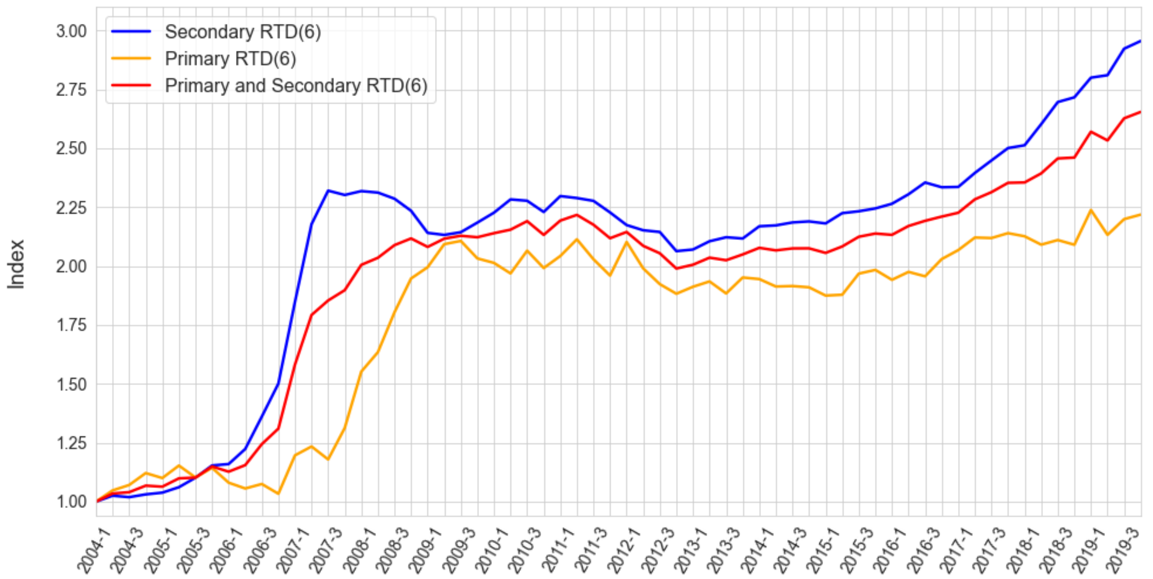
The figure depicts the official consumer price index (CPI) for Poland (source Statistics Poland (https://stat.gov.pl/en/topics/prices-trade/price-indices/). This CPI series is used to deflate the various house-price indices in section 3.

A.2 Nominal price indices

Figure A2: Nominal Price Indices



(a) Warsaw

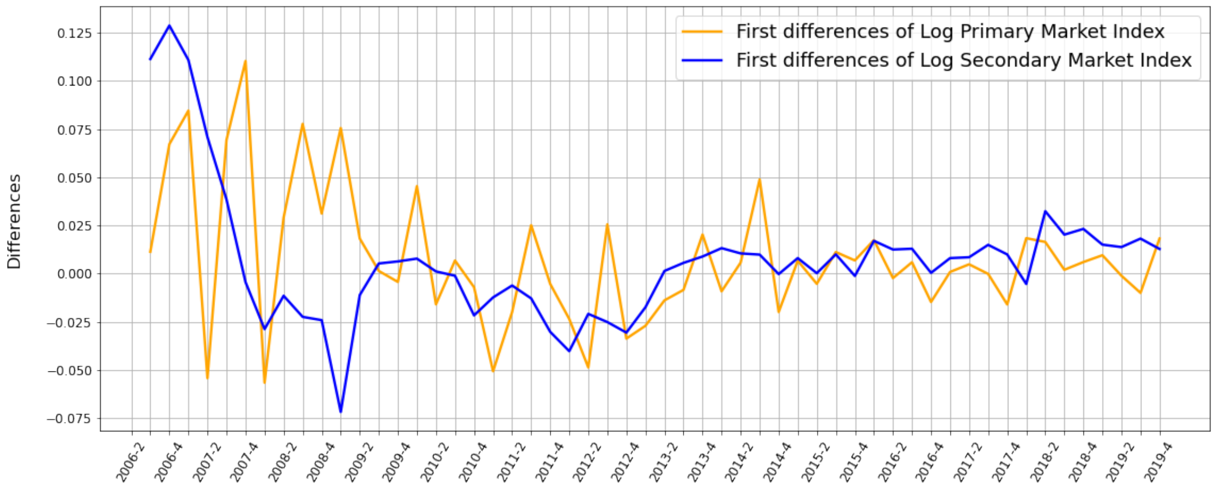


(b) Poznan

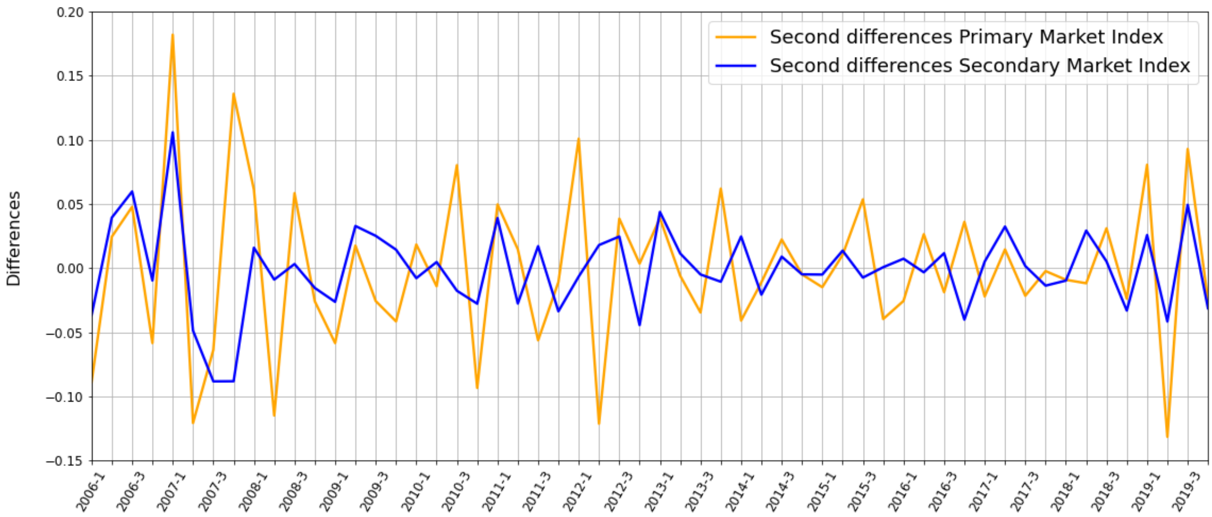
The figure illustrates the development of nominal house-price indices for new and existing apartments as well as a weighted combination of the two indices for Warsaw (a) and Poznan (b). The indices were constructed with the Rolling Time Dummy (RTD) method using a 6-quarter window length.

B Granger Causality

Figure B1: Stationary Price Indices



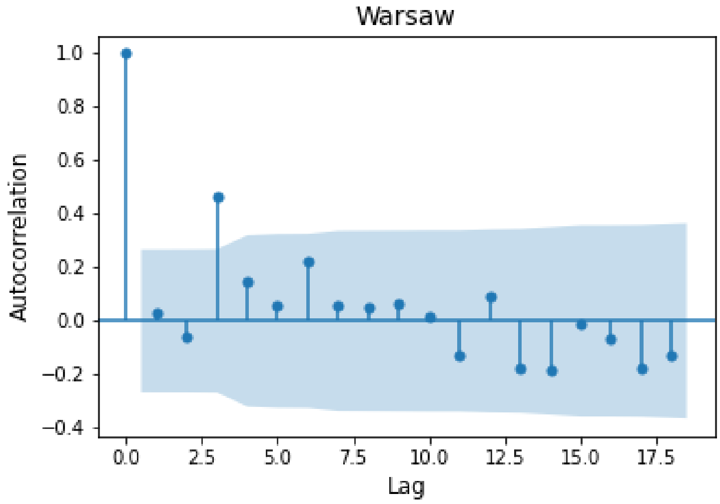
(a) Warsaw



(b) Poznan

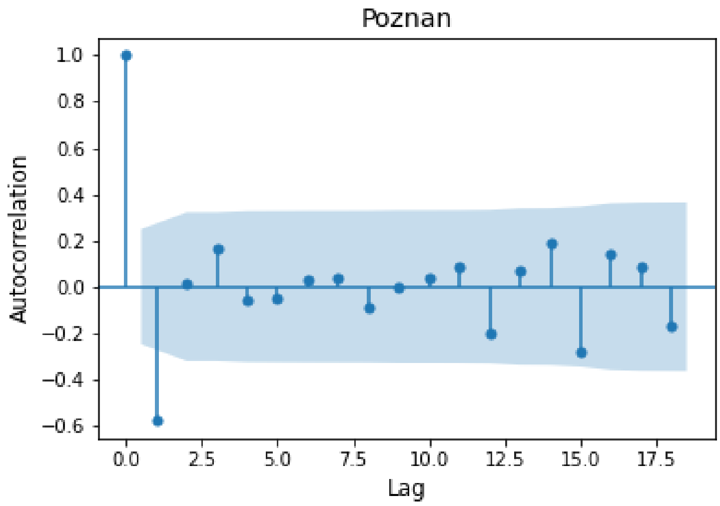
Figure B1 depicts the stationary price indices for new and existing apartments in Warsaw (a) and Poznan (b).

Figure B2: Autocorrelation function for the market for new-builds in Warsaw



The figure illustrates that a lag of 3 quarters (in first differences) is the only significant auto-correlation lag for the new-build market price index for Warsaw.

Figure B3: Autocorrelation function for the market for new-built apartmetns in Poznan



The figure illustrates that a 1-quarter 1-quarter lag (in second differences) is the only significant auto-correlation lag for the new-built apartment price index for Poznan.

Table B1: Model selection with the Akaike Information Criterion (AIC)

Akaike Information Criteria (AIC)		
Lag	Warsaw	Poznan
1	-216.9	-180.3
2	-214.9	-181.8
3	-213.1	**-183.2**
4	-215.3	-179.8
5	-212.5	-174.6
6	-221.2	-170.0
7	-221.2	-172.0
8	**-223.6**	-168.5
9	-221.8	-166.2
10	-218.2	-160.8
11	-215.0	-168.9
12	-212.7	-164.7

The table shows AIC criterion results for models predicting new-built apartment market prices for Warsaw (Poznan) including a three-quarter (one-quarter) auto-regressive lag as well as lags between 1 and 12 for the secondary market.

Figure B4: Model Summary for Warsaw including only the new-built apartment market (7)

```
                                OLS Regression Results
=======================================================================================
Dep. Variable:         primary market   R-squared (uncentered):                   0.276
Model:                            OLS   Adj. R-squared (uncentered):              0.261
Method:                 Least Squares   F-statistic:                              19.05
Date:                Sat, 21 Aug 2021   Prob (F-statistic):                    6.38e-05
Time:                        08:35:15   Log-Likelihood:                          110.38
No. Observations:                  51   AIC:                                     -218.8
Df Residuals:                      50   BIC:                                     -216.8
Df Model:                           1
Covariance Type:            nonrobust
=================================================================================
                  coef    std err          t      P>|t|      [0.025      0.975]
---------------------------------------------------------------------------------
primary_lag_3   0.4777      0.109      4.365      0.000       0.258       0.698
==============================================================================
Omnibus:                        0.668   Durbin-Watson:                   1.921
Prob(Omnibus):                  0.716   Jarque-Bera (JB):                0.269
Skew:                           0.167   Prob(JB):                        0.874
Kurtosis:                       3.123   Cond. No.                         1.00
==============================================================================

Notes:
[1] R² is computed without centering (uncentered) since the model does not contain a constant.
[2] Standard Errors assume that the covariance matrix of the errors is correctly specified.
```

Figure B5: Model Summary for Warsaw including the market for existing apartments (8)

```
                            OLS Regression Results
=======================================================================================
Dep. Variable:                      y   R-squared (uncentered):                   0.536
Model:                            OLS   Adj. R-squared (uncentered):              0.423
Method:                 Least Squares   F-statistic:                              4.753
Date:                Sat, 21 Aug 2021   Prob (F-statistic):                    0.000310
Time:                        08:02:23   Log-Likelihood:                          120.81
No. Observations:                  46   AIC:                                     -223.6
Df Residuals:                      37   BIC:                                     -207.2
Df Model:                           9
Covariance Type:            nonrobust
=================================================================================
                    coef    std err          t      P>|t|      [0.025      0.975]
---------------------------------------------------------------------------------
primary_lag_3     0.1939      0.099      1.956      0.058      -0.007       0.395
sec_lag_1         0.2862      0.223      1.284      0.207      -0.166       0.738
sec_lag_2         0.3017      0.239      1.263      0.215      -0.182       0.786
sec_lag_3         0.0286      0.232      0.123      0.903      -0.441       0.498
sec_lag_4        -0.5051      0.230     -2.192      0.035      -0.972      -0.038
sec_lag_5         0.2095      0.234      0.895      0.377      -0.265       0.684
sec_lag_6         0.0493      0.225      0.219      0.828      -0.407       0.506
sec_lag_7        -0.1461      0.240     -0.608      0.547      -0.633       0.341
sec_lag_8         0.5382      0.175      3.072      0.004       0.183       0.893
==============================================================================
Omnibus:                        3.403   Durbin-Watson:                   2.393
Prob(Omnibus):                  0.182   Jarque-Bera (JB):                2.628
Skew:                           0.580   Prob(JB):                        0.269
Kurtosis:                       3.158   Cond. No.                         6.65
==============================================================================

Notes:
[1] R² is computed without centering (uncentered) since the model does not contain a constant.
[2] Standard Errors assume that the covariance matrix of the errors is correctly specified.
```

Figure B6: Model Summary for Poznan including only the new-built apartment market (7)

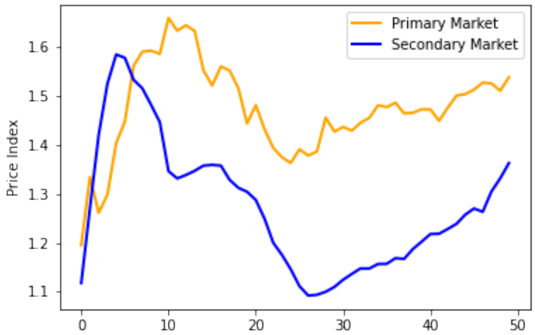
```
                            OLS Regression Results
==============================================================================
Dep. Variable:         primary market   R-squared:                       0.335
Model:                            OLS   Adj. R-squared:                  0.323
Method:                 Least Squares   F-statistic:                     29.17
Date:                Wed, 25 Aug 2021   Prob (F-statistic):           1.29e-06
Time:                        08:54:22   Log-Likelihood:                 92.110
No. Observations:                  59   AIC:                            -182.2
Df Residuals:                      58   BIC:                            -180.1
Df Model:                           1
Covariance Type:            nonrobust
=================================================================================
                    coef    std err          t      P>|t|      [0.025      0.975]
---------------------------------------------------------------------------------
primary_lag_1    -0.5748      0.106     -5.401      0.000      -0.788      -0.362
==============================================================================
Omnibus:                        6.280   Durbin-Watson:                   2.521
Prob(Omnibus):                  0.043   Jarque-Bera (JB):                5.799
Skew:                           0.525   Prob(JB):                       0.0551
Kurtosis:                       4.120   Cond. No.                         1.00
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.
```

Figure B7: Model Summary for Poznan including the market for existing apartments (8)

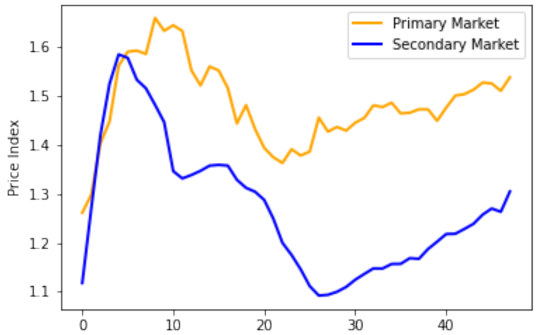
```
                            OLS Regression Results
=======================================================================================
Dep. Variable:                      y   R-squared (uncentered):                   0.409
Model:                            OLS   Adj. R-squared (uncentered):              0.366
Method:                 Least Squares   F-statistic:                              9.523
Date:                Tue, 14 Sep 2021   Prob (F-statistic):                    6.35e-06
Time:                        12:53:11   Log-Likelihood:                          95.616
No. Observations:                  59   AIC:                                     -183.2
Df Residuals:                      55   BIC:                                     -174.9
Df Model:                           4
Covariance Type:            nonrobust
=================================================================================
                    coef    std err          t      P>|t|      [0.025      0.975]
---------------------------------------------------------------------------------
primary_lag_1    -0.5950      0.120     -4.967      0.000      -0.835      -0.355
sec_lag_1        -0.2883      0.232     -1.244      0.219      -0.753       0.176
sec_lag_2         0.0292      0.315      0.093      0.926      -0.603       0.661
sec_lag_3         0.4386      0.240      1.825      0.073      -0.043       0.920
==============================================================================
Omnibus:                        4.413   Durbin-Watson:                   2.467
Prob(Omnibus):                  0.110   Jarque-Bera (JB):                5.198
Skew:                           0.063   Prob(JB):                       0.0744
Kurtosis:                       4.449   Cond. No.                         4.22
==============================================================================
```

C Shift of the primary market

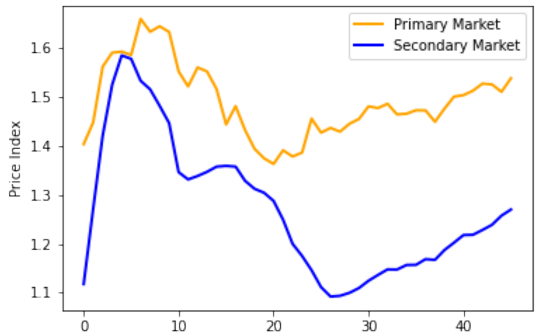
Figure C1: New and existing Housing Market in Warsaw with Different Time Lags



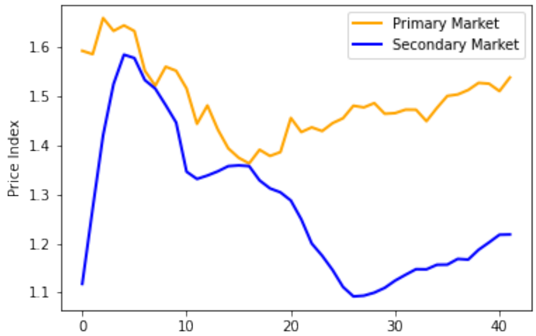
(a) Market for new-built Apartments Lagged by 2 Quarters



(b) Market for new-built Apartments Lagged by 6 Quarters



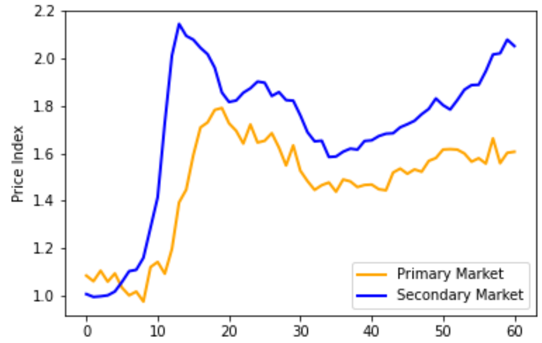
(c) Market for new-built Apartments Lagged by 8 Quarters



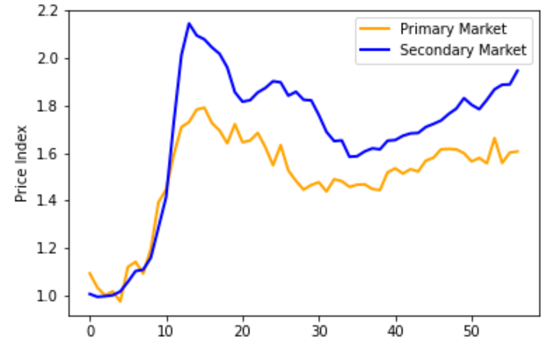
(d) Market for new-built Apartments Lagged by 12 Quarters

The above graphs illustrate the same results as Figure 3, but instead of using the stationary series (i.e. first difference lags for Warsaw), it shifts the house price index for new-builds by 2 (a), 6 (b), 8 (c), or 12 (d) quarters compared to that of existing apartments.

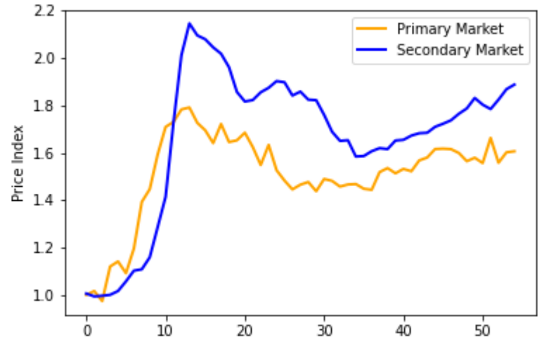
Figure C2: Housing Markets for new and existing apartments in Poznan with Different Time Lags



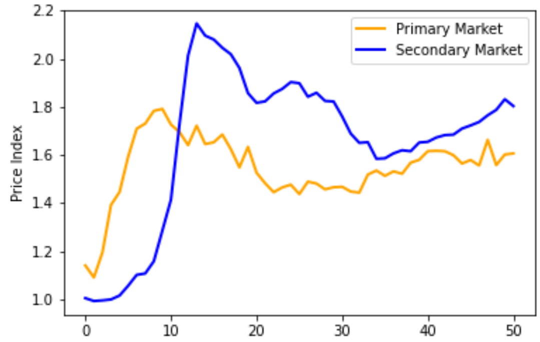
(a) Market for new-built Apartments Lagged by 2 Quarters



(b) Market for new-built Apartments Lagged by 6 Quarters



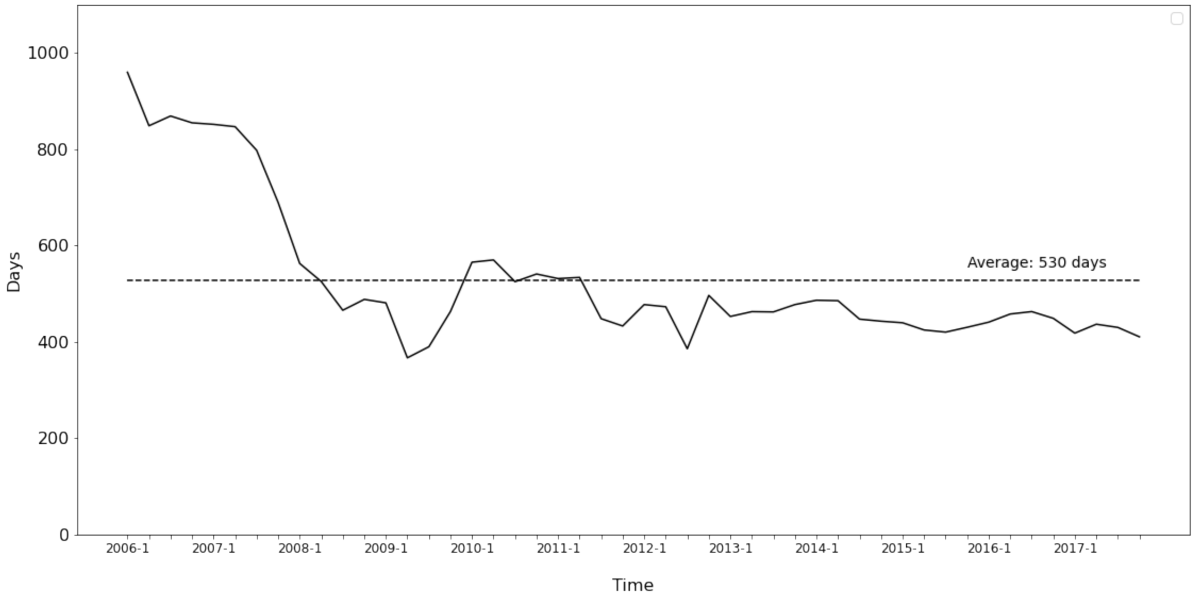
(c) Market for new-built Apartments Lagged by 8 Quarters



(d) Market for new-built Apartments Lagged by 12 Quarters

The above graphs illustrate the same results as Figure 4, but instead of using the stationary series (i.e. third difference lags for Poznan), it shifts the house price index for new-builds by 2 (a), 6 (b), 8 (c), or 12 (d) quarters compared to the price index for existing apartments.

Figure C3: Average Number of Days between Pre-Agreement and Final Transaction



The figure illustrates the average period between signing preliminary agreements and transaction for apartments in Warsaw.