Economics Bulletin

Volume 40, Issue 4

House prices and fertility in South Africa: A spatial econometric analysis

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Abstract

In this paper, the effect of house prices on fertility is analysed across South African provinces using spatial Durbin model. Empirical results using provincial annual data from 1998 to 2015 indicate that housing market plays an important role in the fertility decision besides female job participation and labour market condition. Particularly, an increase in regional house prices results in a decrease in local and subsequently national fertility rate. However, the spillover effect to adjacent provinces appears to be positive and significant, except in the small housing segment; suggesting that an increase in regional house prices will spur fertility in other regions. Intuitively, house price inflation in a province makes housing relatively affordable in adjacent regions; housing affordability being an important driver of fertility. Alternatively, this positive effect might also capture the income effect felt by homeowners following a rise in house prices, which might in turn be favourable to fertility due to financial edge. The insignificant indirect effect from the small housing segment might reflect the fact that small houses are less likely to be the family residential choice. These findings confirm the importance of spatiotemporal economic behavior in shaping regional fertility in South Africa.

The authors are grateful to the associate editor, Prof. Gueorgui I. Kolev and two anonymous referees for their comments and suggestions, which improved the quality of this paper. The financial support provided by the South African National Research Foundation (Grant No. TTK150707123686) is also gratefully acknowledged.
Citation: Beatrice D. Simo-Kengne and Lumengo Bonga-Bonga, (2020) "House prices and fertility in South Africa: A spatial econometric analysis", *Economics Bulletin*, Volume 40, Issue 4, pages 3193-3210
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Submitted: July 13, 2020. **Published:** December 14, 2020.

1- Introduction

Literature abounds on how macroeconomic and financial variables interact with housing prices. For example, Cho (2011) investigates the effect of house price changes on consumption using household level data from Korea. Empirical results show that housing price do not affect total household consumption in Korea. According to the author, this neutral effect is explained by the fact that a positive wealth effect of homeowners, associated with the increase in home prices, is offset by a negative wealth effect of non-homeowners related to high rental cost. Still on the importance of housing price on consumption. Dong et al. (2017) show that the effects of housing price on consumption in 35 major cities in China are asymmetric in that the wealth effect and the substitution effect depend on a specific threshold determined by the housing prices. Moreover, many studies have alluded to the interaction between housing price and monetary policy stance. For example, Amador-Torres et al. (2018) assess the determinants of housing price bubbles' duration for a set of OECD countries between 1970 and 2015. The authors show that a prolonged domestic monetary policy easing increase the duration of housing price bubbles and the tightening of monetary policy contributes in accelerating the termination of a housing bubble in OECD countries. Hui and Ng (2016) assess the relationship between housing price and mortgage lending in two housing sub-market of Hong Kong by distinguishing between mass housing market and the luxury housing market. The authors find a one-way relationship in that both types of housing markets affect mortgage lending, while the change in mortgage lending has no effect in the housing market in Hong-Kong.

However, there are limited studies that relate the housing market and demographic-related variables, such as fertility. Clark and Ferrer (2019) assess the effect of housing price on fertility in Canada by combining longitudinal data from the Canadian Survey of Labour Income Dynamics (SLID) with housing price data from the Canadian Real Estate Association. For the authors, the rationale of the relationship between house price and fertility is supported by the fact that higher housing prices may lead homeowners to desire more children, especially if they have low substitution between children and other goods in their utility function. Nonetheless, high housing prices might negatively affect the fertility decision of renters for the same reason. The empirical results show that lagged housing prices have a positive effect on marginal fertility for homeowners. However, for renters the authors find no significant effects. Mizutani (2015) attempts to evaluate empirically how household resources, especially housing wealth, affect fertility decision in Japan. Making use of data from the Japanese Panel Survey of Consumers, the author finds that an increase in home value increases the possibility of homeowners with housing loans to bear a child. However, for homeowner without housing loans and renters, the change in housing wealth has no effect on fertility decision. Lin et al. (2016) assess how various housing options impact on fertility decision in Taiwan. These options include renting, owning, living with parents or siblings, living in house bought by parents and living in staff housing. Making use of micro-data obtained from the Taiwanese Panel Study of Family Dynamics (PSFD), the authors find that homeowners have their first child at an old age and families living with their siblings bear their first child at a younger age.

While many studies on the housing price and fertility nexus focus on how different characteristics of housing homeownership affect fertility decisions, none of the studies on this topic have addressed the issues of spatial interaction and structure in housing prices and their effects on fertility decisions. A number of studies discuss the diffusion effects of housing prices by assessing how shocks in one region may spread to neighbouring regions. For example, in assessing the relationship between housing price and economic growth, Simo-Kengne et al. (2012) show that spatial effects are highly important in the South African housing markets and they need to be taken into account when assessing the link between housing price and economic growth at provincial or regional level. Moreover, geo-statistical spatiotemporal methods have recently been documented to be useful for modeling fertility dynamics (De Iaco et al. 2015). This indicates that spatial dependence is indeed an important characteristic of the data generating process of fertility evolution. Another shortcoming in the literature on the link between housing prices and fertility reside on the coverage of past studies. While fertility issues are important in the African continent, none of the past studies endeavour to assess how housing prices affect fertility in the continent. In order to remedy these shortcomings, this paper contributes to the literature on housing price and fertility nexus in three ways. Firstly, the paper accounts for spatial interaction between different locations and potential endogeneity that may arise from simultaneity, measurement errors and omission bias as discussed in the data section. To this end, use is made of different identification strategies (Islama et al. 2019) as well as a spatial econometrics estimation approach. Secondly, the paper disaggregates a specific segment of housings into different sections, i.e., the middle housing segment, which is the focus of this study, is subdivided into three different sections: the large-middle section (221 square meters–400 square meters), the medium middle section (141 square meters–220 square meters), and the small-middle section (80 square meters–140 square meters). Thirdly, this is the first paper, to the best of our knowledge, which focuses on the issue of housing price and fertility in the African continent, especially in South Africa. Studies show that fertility stalls in Sub-Saharan African are not widespread compared to other continents (see Schoumaker, 2019). Thus, it is important to analyse the contribution of housing prices in determining fertility decision in Africa.

This paper will focus on South Africa by assessing how the interaction between the different provinces of the country contributes to the relationship between house prices and fertility. The choice of South Africa is important given the high development of its property market compared to other Sub-Saharan African countries. South Africa’s residential property market is the largest section of the South African property market, comprising the majority of property assets within the country and an important component of household wealth. CAHFA (2019) shows that the growth of residential property value outpaces interest on savings, salary increases, and most businesses, and that homeownership is among the most powerful ways for wealth creation in South Africa.

The remainder of the paper is structured as follows. Section 2 describes the methodology and the data used in the paper, section 3 presents the estimation and discusses the main results and section 4 concludes the paper.

2. Methodology and data

Assuming that fertility and house prices are geospatial stochastic processes. This may lead to the following general specification:

$$TFR_{it} = \rho WTFR_{it} + \beta X_{it} + \gamma WX_{it} + \theta Wu_{it} + \varepsilon_{it} \quad (1)$$

where TFR is the fertility variables proxied by the total fertility rate, X is the vector of covariates including female labour force participation (FLFP), real wage (RW) and the real house prices. Based on the availability of the data, different housing sizes are considered including the entire middle segment (THP), the large middle (LHP), the medium middle (MHP) or the small middle (SHP). Besides the geospatial characteristic of fertility, spatial autocorrelation is expected to occur through X variables, namely real house prices, real wage and labour force participation. The rationale behind this choice stands from the importance of internal migration due to relocation and job opportunity, which in turn, fuel regional dependencies. The subscripts i and t denote provinces (see Appendix A for the South Africa regional map) of South Africa and time dimension, respectively. Three nested scenarios can be obtained from Equation (1). W represents the weight matrix.

When $\theta = 0$, Equation (1) becomes a Spatial Durbin Model (SDM)[1] with the following specification:

$$TFR_{it} = \rho WTFR_{it} + \beta X_{it} + \gamma WX_{it} + \varepsilon_{it} \quad (2)$$

Unlike binary weights, our study uses the distance weight based on the assumption that regions that do not share border might exhibit spatial dependence based on their geographical coordinates. Accordingly, the distance weight is defined as:

$$W_{ij} = \begin{cases} \frac{1}{d_{ij}} & if\ i \neq j \\ 0 & if\ i = j \end{cases} \quad (3)$$

with d_{ij} representing the distance between the geographical centers of both regions i and j.

Besides the benefits of the traditional panel techniques, the major attraction of the considered models lies on their ability to control for spatial dependence, which is assumed prevalent in characterizing the fertility-housing nexus. In fact, because of internal migration, individuals with different levels of

[1] Besides the classical SDM, a Spatial Durbin Error Model (SDEM) exists, that nests the spatial interaction from exogenous variables and the error term.

fertility appetite might migrate from one region to another; thus affecting the fertility rate of both the origin and the destination regions. Likewise, individuals' decision to relocate might be prompted by regional dissimilarities in fertility drivers such as labour market conditions and socioeconomic characteristics. This leads to the conjecture that spatial interaction, if any, affecting the fertility-housing nexus may originate from the fertility and/or its determinants (known and unknown). Of central interest is the housing determinant of fertility and this study hypothesizes and tests the indirect effect of housing prompted by migration on provincial fertility rate. In other words, house price variations in one province might affect interprovincial fertility rate.

From the statistics perspective, the overall scenario of fertility changes at the interregional level is referred to as global spatial autocorrelation and investigated using the Global Moran's I index. This global spatial autocorrelation test uses a spatial matrix to analyse the similarity between units in each province and adjacent provinces (Griffith, and Anselin, 1989).

If W is the spatial weight matrix, Moran's I is computed as follow:

$$Moran's\ I = N\frac{\sum_{i=1}^{N}\sum_{j=1}^{N} W_{ij}\,(x_i-\bar{x})(x_j-\bar{x})}{\sum_{i=1}^{N}\sum_{j=1}^{N} W_{ij}\ \sum_{i=1}^{N}(x_i-\bar{x})^2} = \frac{\sum_{i=1}^{N}\sum_{j=1}^{N} W_{ij}\,(x_i-\bar{x})(x_j-\bar{x})}{\sigma^2\sum_{i=1}^{N}\sum_{j=1}^{N} W_{ij}} \tag{4}$$

where $\bar{x} = \frac{1}{N}\sum_{i=1}^{N} x_i$ and $\sigma^2 = \frac{1}{N}\sum_{i=1}^{N}(x_i - \bar{x})^2$ are respectively the mean and the variance of the observations across provinces. x_i and x_j denote the observations in ith and jth spatial unit, respectively. N is the number of Provinces. Moran's I Index ranges between [-1, 1] with the high (low) value indicating the strong (weak) group. If Moran's I >0, there is a positive spatial autocorrelation indicating that a high (low) value unit is adjacent to high (low) value unit. Similarly in the presence of a negative spatial autocorrelation, a high (low) value unit is adjacent to low (high) value unit. Finally, when Moran's I=0, there is no spatial autocorrelation.

The significance of the spatial autocorrelation index is given by the standardized statistics given by:

$$Z = \frac{I-E(I)}{\sqrt{V(I)}} \tag{5}$$

where I is the Moran's I; $E(I)$ and $V(I)$ denoting the mean and the variance of the Moran's I, respectively. At the conventional level of significance (5%), the spatial autocorrelation is significant if $|Z| > 1.96$.

Based on the availability of provincial data for all the variables understudied, the empirical investigation covers the sample period from 1998 to 2015 for the nine (9) South African provinces. Apart from the fertility, all the variables were obtained through Quantec Easy Data. House prices data are compiled by the Allied Bank of South Africa (ABSA), which classifies housing into three main segments depending on the price: the luxury segment (ZAR 3.5 million–ZAR 12.8 million), the middle segment (ZAR 480,000–ZAR 3.5 million), and the affordable segment (below ZAR 480,000 and area between 40 square meters–79 square meters). This study analyses the middle housing segment, as regional data are not available for the luxury and affordable categories. In addition the middle housing segment is grouped into three more sections depending on the size: the large-middle section (221 square meters–400 square meters), the medium middle section (141 square meters–220 square meters), and the small-middle section (80 square meters–140 square meters). This makes it possible a disaggregated analysis of the middle house prices in relation to fertility; that is, total middle real house prices and three corresponding subcategories: the large-middle real house prices, the medium middle real house prices and the small middle real house prices.

The ABSA house price index and the First National Bank (FNB) house price index are two widely quoted house price indices in South Africa. However, the low-commission estate agency HomeBid considers these indexes as inaccurate because their computation is based on home loans approved by these banks rather than deeds-office data, which are thought to be "cleaned" as they include properties bought new[2]. Despite the possible induced measurement errors, ABSA house price index remains the most comprehensive property index, continuously available at both national and regional levels over a long period. It uses smoothing procedure to adjust for seasonal distortions and outliers; hence representing the best proxy for spatial-dynamic house price analysis. Similarly, while the regional fertility data is not available in South Africa, the authors make use of the regional birth registration data to approximate the total fertility using the formula: TFR = 5 ∑ ASFRa (for 5-year age groups) where ASFRa = age-specific fertility rate for women in age group *a* (approximated by the ratio number of live birth/number of women).

The induced computational flaw of these proxies can be assimilated to measurement errors, which represent a well-documented source of endogeneity and are likely to result in confounded estimates if not controlled for. In addition, the estimation is carried out at the provincial rather than individual level, some important variables being omitted from the regression. Illustratively, while fertility impact of house prices fluctuations is expected to be different across homeowners and renters, the available house prices dataset contain no homeownership variables. Theoretically, higher house prices tend to cause renters to delay and/or tighten fertility decision while homeowners are likely to experience opposite effect. Therefore, the omission of ownership may lead to a possible omitted variable bias, which represents another source of endogeneity. Finally, because demographic development affect housing markets, a plausible feedback effect is expected from fertility to house prices and this gives rise to a potential endogeneity led simultaneity bias.

Therefore, we propose two identification strategies to mitigate the issue of endogeneity. The first strategy relies on the intuition that lagged regressors are less likely to have non-zero correlation with contemporaneous errors and as such, regressing a contemporaneous dependent variable on lagged

[2] https://www.iol.co.za/personal-finance/why-house-price-indices-differ-1987296

regressors is an option to circumvent the endogeneity. This intuition is consistent with the rationale that economic variables in general and house prices in particular have rather a delayed impact on the fertility decision. Considering that fertility decision can be planned in a short or long term, use is made of one lag and five lags corresponding to short and long term fertility planning, respectively. Accordingly, the baseline model is modified as follows:

$$TFR_{it} = \rho WTFR_{it} + \beta X_{it-l} + \gamma WX_{it-l} + \varepsilon_{it} \qquad \text{with } \; l = 1, 5 \tag{6}$$

Practically, the estimation of equation (6) implies the use of different samples for the dependent and independent variables, hence representing the shortcoming of this identification strategy.

The second identification scheme is built from the two stage least square intuition, where equation (2) uses the predicted values of house prices obtained from a first step estimation regressing house prices on an instrument (see equation(7)). Since interest rate is an important driver of house prices and is is unlikely to have a direct impact on the fertility decision, we use real lending rate (RLR) as instrument for house prices. With the common monetary policy across all provinces, we obtain regional lending rate by deflating the national nominal lending rate from provincial level inflation proxied by the GDP deflator; all the data obtained from Quantec database. Consistently with equation (2), real house prices are assumed to have a spatial representation in which both dependent and independent variables are involved in the spatial transmission mechanism.

$$y_{it} = \rho' W y_{it} + \beta' X'_{it} + \gamma' W X'_{it} + u_{it} \tag{7}$$

Where y is real house price variable (THP, LHP, MHP or SHP), X' vector includes the instrument (RLR) and the rest of covariates (FLFP, RW). Since house prices in a particular province are likely to be affected by labour and housing market conditions in contiguous provinces, spatial dependence channels through FLFP, RW and RLR besides real house price variable.

The second stage estimation uses the predicted real house prices from equation (7) in estimating equation (2). This procedure is thought to produce consistent estimates of equation 2 although their standard errors may be invalid due to the fact that one of the explanatory variables is an estimate itself. We use a bootstrap procedure with 2000 replications to correct the standards errors.

Table 1. Summary statistics

Panel A. Descriptive statistics					
	Obs	Mean	Std. Dev.	Min	Max
TFR	162	1.2214	0.3150	0.6646	2.0574
THP	162	14.6253	0.6402	13.3732	15.6505
LHP	162	14.9471	0.6760	13.5960	16.9975
MHP	162	14.5640	0.6604	13.2728	15.6028
SHP	162	14.2750	0.6166	13.0444	15.3067
FLFP	162	3.7964	0.2005	3.3729	4.1674
RW	162	11.3888	0.8221	9.7107	13.2514
RLR	162	0.5228	0.03829	-0.0342	0.1971

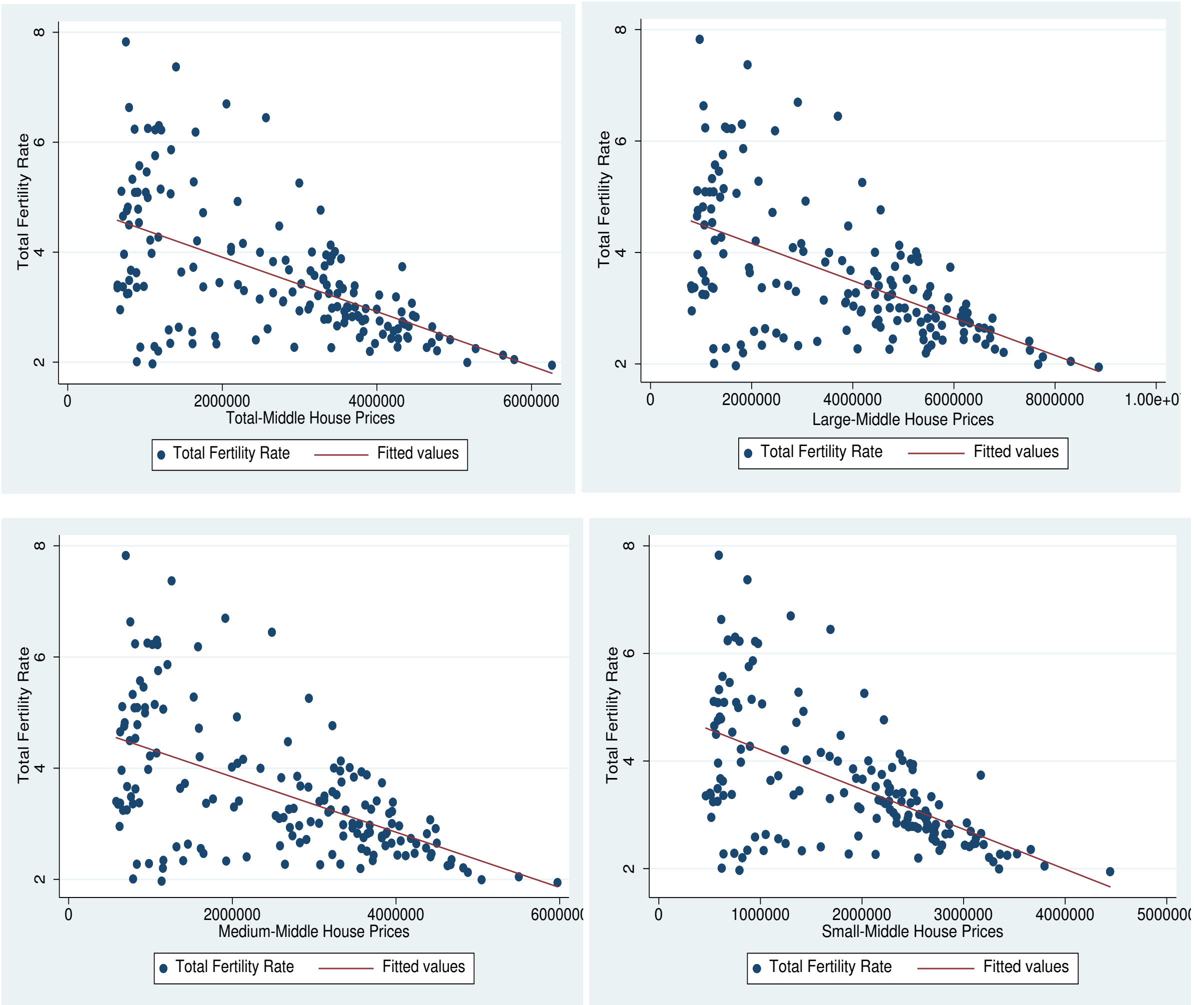
Panel B. Panel Unit root test			
	Fisher test based on ADF test	IPS test	Decision
TFR	31.166**	-1.49*	I(0)
THP	77.387***	-2.972***	I(0)
LHP	76.252	-2.862***	I(0)
MHP	74.602***	-2.728***	I(0)
SHP	27.815*	-1.971**	I(0)
FLFP	61.740***	-1.529*	I(0)
RW	44.007***	-1.306*	I(0)
RLR	19.8697	-1.4231*	I(0)

Panel C. Spatial detection test			
	Global spatial autocorrelation (Global Moran MI and Robust LM test)	Spatial dependence (Pesaran CD test)	Serial autocorrelation (Wooldridge F-test)
Total-Middle Housing Segment	Global Moran MI=-0.169*** Robust LM=33.241***	9.796***	28.166***
Large-Middle Housing Segment	Global Moran MI=-0.162*** Robust LM=33.36***	9.347***	29.695***
Medium-Middle Housing Segment	Global Moran MI=-0.168*** Robust LM=33.49***	9.179***	26.446***
Small-Middle Housing Segment	Global Moran MI=-0.17*** Robust LM=28.03***	9.461 ***	27.030***

Note. The variables are all in their logarithm forms. *** p<0.01, ** p<0.05, * p<0.1. If the general global spatial autocorrelation can well be detected using the Moran's I, it is unlikely to depict the source of spatial connection, which can occur through observed (spatial lag model) and unobserved variable (spatial error model). To complement MI, the robust-LM test is provided, which is robust in the presence of spatial lag models or spatial error models.

As summarized in Table 1, the regional average real house prices in log form ranges from 14.27 to 14.95 across housing categories while the standard deviation is about 0.6, suggesting that the prices of housing in the middle segment are very close to each other. In addition, the average total fertility rate is 1.2214 in log form; that is about 3 children over the sample period consistently with the average national TFR of 2.61 over the same sample period based on fertility data extracted from the Federal Reserves of St Louis database. This implies a minimum computation bias in our regional TFR, which is thus, believed to be of marginal impact on the empirical results.

Figure 1: Total fertility rate and real house prices across housing segments



Although a visual inspection depicts an inverse relationship between real house prices and fertility rate (See Figure 1), such relationship is subject to a number of relevant econometric issues (stationarity, spatial dependence, heterogeneity and endogeneity) which require further analyses to derive valid inference. The stationary property of the variables is worth noting. This is important as it determines the appropriateness of the estimation techniques. Panel B of Table 1 displays the panel unit root test results and all the variables appear to be stationary, that is I(0) based on Fisher type panel unit root test.

Finally, the spatial diagnostic tests provided in Panel C (Table 1) confirm the presence of global autocorrelation. The Moran's I index is statistically significant and negative across the different housing segment considered indicating that province with high house price index is adjacent with low house price index province and vice versa. This is quite intuitive as individuals are likely to move from high (low) house price region to low (high) ones. In addition, the robust LM test result is favourable to the existence of spatial autocorrelation whether from spatial lag origin or from spatial error cause. Given that spatial autocorrelation implies dependence across spatial units as well as serial autocorrelation, the

Pesaran CD test of cross sectional dependence and the Wooldridge F-test of serial correlation could not reject this assumption. It appears that provinces exhibit a strong dependence to each other with significant serial autocorrelation of errors, at least for the first order. This diagnostic outcome motivates the use of spatial panel estimators.

3. Empirical results

The baseline outputs from non-spatial regressions are provided in Table 2 and indicate an insignificant effect of house prices on fertility rates. Interesting to note is that, once endogeneity and heterogeneity are accounted for, housing prices tend to have negative effect on fertility although insignificant in most instances. These results remain informative and point to the imperative to control for endogeneity and heterogeneity. In addition, Hausman test highlights the relevance of random effects (RE) over fixed effects alternative.

Besides endogeneity, the use of SDM to analyze the impact of house prices on fertility rate is reasonable as the spatial autoregression coefficients are all significant. As displayed in Table 3, rho coefficients across housing segment are very close and relatively high in absolute term, irrespective of the model. However, controlling for endogeneity based on lag regressors produces smaller rho coefficients than that obtained from the two stage regression. They are all negative; suggesting that fertility rate in a particular province is negatively affected by fertility changes in adjacent provinces. This is likely to be the case for rural and urban provinces where consistently with the spatial literature, there is a trending divergence in fertility between rural and urban areas. Accordingly, decreasing fertility rates in urban provinces due to high house prices may result in migration to rural areas with affordable housing conditions that are favourable to fertility expansion.

Regarding the spatial effect through explanatory variables, it is indispensable to estimate the marginal effects as the spatial coefficient can be misleading. According to LeSage and Pace (2009), the correct spatial spillover effects of variables should be explained in terms of direct and indirect effects as the significance of the coefficent estimates cannot compare between non-spatial and spatial models. Table 4 displays the marginal effects decomposed into direct, indirects and total effects of explanatory variables on fertility rate. It emerges that real house prices exhibit a negative effect on fertility rate with downward sloping endogeneity bias as the estimates become greater in absolute values once endogeneity is controlled for. Similarly, the goodness of fit tends to improve after controlling for endogeneity. Therefore, the inference is based on the last three columns of Table 4, which are estimated marginal effects from endogeneity-free models.

Starting from the house prices, the direct and total effects are negative and significant across housing categories. The increase in regional house prices will result in a decrease in the local and eventually national fertility rate. Therefore, 1 percent increase in provincial house prices is likely to dampen the local fertility rate by a percentage point ranging from 0.2961 to 0.4766, across housing segments. This single percentage point increase in house prices across different segments will further translate into a decline in the national fertility rate ranging from 0.0573 to 0.2279 percentage point, across housing categories.

However, the indirect effect of house prices is positive across housing segments and significant. This implies that increasing real house prices in a particular province will likely rise fertility rate in adjacent provinces. This is unsurprising since house price inflation in one province makes housing relatively affordable in adjacent regions; housing affordability being an important driver of fertility (Clark, 2012). Alternatively, this positive effect migt also capture the income effect felt by homeowners following a rise in house prices, which in turn encourages more babies as income increases. Therefore, due to positive spilover effects in regional real house prices (see first stage output from Table 5 in Appendix), the wealth effect felt by homeowners following house prices growth in a particular province will spillover onto adjacent provinces, resulting in fertility development of homeowners. However, this positive outcome is offset by the opposite effect felt by renters, leading to a net negative outcome as illustrated by the negative net effect.

Table 2. Non-spatial estimates of house prices on fertility across South African provinces

	POLS	1-year lag POLS	5-year lag POLS	IV-2SLS	FE/RE	1-year lag FE/RE	5-year lag FE/RE	IV-FE/IV-RE
Panel A. Total-Middle Housing Segment								
THP	0.1790	0.0649	-0.2185	0.5546	-0.1469	-0.1888	-0.4053***	1.1541
FLFP	-0.0641	-0.3466	-1.2123**	-1.1244***	-0.9133***	-0.9203***	-0.8664***	-1.1721***
RW	0.6777**	0.4316	0.4119	-0.0671	0.1880	0.0312	0.0778**	-0.1514
R^2	*0.7924*	*0.7991*	*0.8200*	*0.6666*	*0.7289*	*0.7522*	*0.8025*	*0.5671*
Hausman	---	---	---	---	*17.19(0.6404)*	*8.02(0.9864)*	*2.27(0.9999)*	*5.94(0.9990)*
Panel B. Large-Middle Housing segment								
LHP	-0.1952	-0.2955	-0.2245	0.3488	-0.2183	-0.2575*	-0.2821**	0.3488
FLFP	0.0821	-0.1923	-1.1463**	-1.0815***	-0.8771***	-0.9000***	-0.8844***	-1.0815***
RW	0.5196	0.2531	0.3364	-0.0491	0.03091	0.0448	0.0676**	-0.0491
R^2	*0.7930*	*0.8021*	*0.8208*	*0.6707*	*0.7325*	*0.7559*	*0.8010*	*0.6726*
Hausman	---	---	---	---	*13.93(0.8343)*	*6.32(0.9971)*	*1.17(1.0000)*	*2.34(1.0000)*
Panel C. Medium-Middle Housing Segment								
MHP	-0.1021	-0.2317	-0.3481	0.7529	-0.1584	-0.2373	-0.3113**	-1.6318
FLFP	0.0212	-0.2542	-1.1634***	-1.0973***	-0.8890***	-0.9037***	-0.8922***	0.5875
RW	0.5980**	0.3572	0.4238	-0.0993	0.0183	0.0369	0.0657**	0.3130
R^2	*0.7920*	*0.8011*	*0.8231*	*0.5747*	*0.7289*	*0.7544*	*0.8012*	*0.4322*
Hausman	---	---	---	---	*14.11(0.8248)*	*6.19(0.9974)*	*2.14(1.0000)*	---------
Panel D. Small-Middle Housing Segment								
SHP	0.3213	0.2147	-0.0834	0.49951	0.0398	0.0053	-0.2390*	1.1633
FLFP	-0.0828	-0.3875	-1.2520***	-1.1847***	-0.9126***	-0.9299***	-0.8575***	-1.2422**
RW	0.7345**	0.4686	0.4526	-0.0318	-0.0067	0.0034	0.0380	-0.0940
R^2	*0.7958*	*0.8008*	*0.8191*	*0.6801*	*0.7190*	*0.7432*	*0.7939*	*0.5183*
Hausman	---	---	---	---	*18.75 (0.5383)*	*8.81(0.9765)*	*4.19(0.9970)*	*8.08(0.9913)*

Note. All the variables are in logarithm form. For IV estimators (columns 4 and 8), the figures reported are second stage results. POLS estimates include both province specific and time effects although not reported. THR, LHP, MHP, SHP, FLFP and RW are lagged 1 year (in columns 2 and 6) and 5 years (in columns 3 and 7). IV-RE estimation could not converge for Medium-Middle Housing Segment (panel C, column 8), hence the missing Hausman statistic and the reported figures are IV-FE estimates.*, ** and *** denote significance at the 10%, 5% and 1% level of significance, respectively.

Table 3: SDM estimates explaining the fertility rate across housing segments

	SDM	1-year lag SDM	5-year lag SDM	2 stage-SDM
Panel A. Total-Middle Housing Segment				
THP	-0.3817*	-0.5689**	-0.7020***	-1.1708***
FLFP	-0.8436***	-0.9201***	-0.8007***	-0.7725***
RW	0.0878**	0.0959***	0.1174***	0.1691***
w*THP	-0.0314	0.1645	0.1725	0.0853
w*FLFP	-0.9734*	-1.1884**	-0.25041	-1.1560**
w*RW	0.4625**	0.2496	-0.0696	0.3489**
Rho	*-0.8618****	*-0.6632****	*-0.7752****	*-0.8776****
sigma	*0.01928****	*0.0179****	*0.0115****	*0.0197****
R^2	*0.7443*	*0.7796*	*0.8229*	*0.7560*
Panel B. Large-Middle Housing Segment				
LHP	-0.4823***	-0.5934***	-0.5532***	-0.5895*
FLFP	-0.8377***	-0.9231***	-0.8348***	-0.8283***
RW	0.1004***	0.1036***	0.1028***	0.1152***
w*LHP	0.0219	0.1988*	0.2224**	0.0217
w*FLFP	-1.1032**	-1.3152***	-0.4721	-1.1152**
w*RW	0.4256**	0.2304	-0.0754	0.4259**
Rho	*-0.8718****	*-0.6584****	*-0.7227****	*-0.8808****
sigma	*0.0186****	*0.01673****	*0.0113****	*0.0194****
R^2	*0.7573*	*0.7930*	*0.8299*	*0.7477*
Panel A. Medium-Middle Housing Segment				
MHP	-0.4191**	-0.5755***	-0.6483***	-1.0680***
FLFP	-0.8306***	-0.9005***	-0.7886***	-0.7769***
RW	0.0923***	0.0978***	0.1086***	0.1564***
w*MHP	-0.0692	0.0947	0.1238	-0.0233
w*FLFP	-0.9809*	-1.1515**	-0.2142	-1.2697***
w*RW	0.5137***	0.3304**	-0.0182	0.5218***
Rho	*-0.9291****	*-0.7627****	*-0.8545****	*-0.9370****
sigma	*0.0188****	*0.0170****	*0.0112****	*0.0191****
R^2	*0.7455*	*0.7812*	*0.8217*	*0.7553*
Panel D. Small-Middle Housing Segment				
SHP	-0.0969	-0.2455	-0.4179***	-0.8815*
FLFP	-0.8514***	-0.8854***	-0.7603***	-0.6518***
RW	0.0538	0.0531*	0.0597**	0.0925**
w*SHP	-0.0791	0.0670	0.1205	0.0019
w*FLFP	-0.8823	-1.0578**	-0.4140	-1.2830**
w*RW	0.4988**	0.3522*	0.0702	0.5079***
Rho	*-0.8486****	*-0.7321****	*-0.8208****	*-0.8819****
sigma	*0.0193****	*0.0177****	*0.0124****	*0.01957****
R^2	*0.7301*	*0.7301*	*0.8012*	*0.7415*

Note. All the variables are in logarithm form. For IV estimators (columns 4), the figures reported are second stage results. All the models control for both province specific and time effects although not reported. THR, LHP, MHP, SHP, FLFP and RW are lagged 1 year and 5 years in columns 2 and 3, respectively. Consistently with the non-spatial output, all the estimates are from random effect specification. *, ** and *** denote significance at the 10%, 5% and 1% level of significance, respectively.

Table 4: Marginal effects of house prices on fertility rate across housing segments

	SDM	1-year lag SDM	5-year lag SDM	2 stage-SDM
Panel A. Total-Middle Housing Segment				
Direct effect				
THP	-0.3026***	-0.4192***	-0.3682***	-0.3080***
FLFP	-0.2360	-0.4982**	-0.9027***	-0.2450
RW	-0.1370	-0.0761	0.0212	-0.1283
Indirect effect				
THP	0.2474**	0.0312***	0.1604	0.2508**
FLFP	0.8371***	0.7797***	0.4340	0.8425***
RW	-0.7037***	-0.7131***	-0.5372*	-0.7050***
Total Effect				
THP	-0.0552	-0.1075**	-0.2078***	-0.0573
FLFP	0.6011**	0.2816	-0.4687	0.5975**
RW	-0.8407***	-0.7892***	-0.5160*	-0.8334***
Panel B. Large-Middle Housing Segment				
Direct effect				
LHP	-0.3542***	-0.4766***	-0.3977***	-0.3127***
FLFP	-0.1385	-0.3884	-0.9218***	-0.1954
RW	-0.1339	-0.0831	0.0084	-0.1301
Indirect effect				
LHP	0.3064***	0.3855***	0.2320**	0.2560**
FLFP	0.7163**	0.6363**	0.3565	0.7963**
RW	-0.7511***	-0.7857***	-0.7353**	-0.7034***
Total Effect				
THP	-0.0478	-0.0911**	-0.1657**	-0.0567
FLFP	0.5777**	0.2480	-0.5653	0.6009**
RW	-0.8860***	-0.8688***	-0.7269*	-0.8335***
Panel A. Medium-Middle Housing Segment				
Direct effect				
MHP	-0.2898***	-0.4143***	-0.3673***	-0.2961***
FLFP	-0.2124	-0.4724*	-0.9290***	-0.2344
RW	-0.1428*	-0.0845	0.0027	-0.1358
Indirect effect				
MHP	0.2312**	0.3096***	0.1935*	0.2379**
FLFP	0.8369***	0.7711***	0.4003	0.8418***
RW	-0.6794***	-0.7066***	-0.6685**	-0.6893***
Total Effect				
MHP	-0.0586	-0.1048***	-0.1738***	-0.0583
FLFP	0.6244**	0.2987	-0.5287	0.6074**
RW	-0.8222***	-0.7911***	-0.6658*	-0.8250***
Panel D. Small-Middle Housing Segment				
Direct effect				
SHP	-0.2603***	-0.3677***	-0.3077***	-0.3042***
FLFP	-0.2519	-0.4826**	-0.8408***	-0.2173
RW	-0.1602*	-0.1013	0.0071	-0.1506*
Indirect effect				
SHP	0.2039**	0.2517***	0.0798	0.2500**
FLFP	0.8779***	0.8040***	0.4292	0.8153**
RW	-0.6644***	-0.64481***	-0.3889	-0.6965***
Total Effect				
SHP	-0.0564	-0.1160***	-0.2279***	-0.0543
FLFP	0.6261**	0.3214	-0.4116	0.5980**
RW	-0.8246***	-0.7461***	-0.3818	-0.8472***

Note. All the variables are in logarithm form. For IV estimators (columns 4), the figures reported are second stage effects. All the models control for both province specific and time effects although not reported. THR, LHP, MHP, SHP, FLFP and RW are lagged 1 year and 5 years in columns 2 and 3, respectively. Consistently with the non-spatial output, all the estimates are from random effect specification. *, ** and *** denote significance at the 10%, 5% and 1% level of significance, respectively.

Similar to house prices, female labour force participation generally has both positive and negative effects. Its direct effect is negative and significant across housing segment, confirming the well documented trade-off between female employment and baby making decision. Accordingly, the increase in regional female work participation will reduce the fertility rate in the local area. On the other hand, the indirect and total effects are positive and significant consistently to the income effect of female labour participation. The increase of female worker in one province will increase the fertility rate in adjacent regions and subsequently the national fertility rate.

Finally, the real wage exhibits a negative effect on fertility rate. The indirect and total effects are negative and significant; implying that fertility in one province is likely to decline as a result of increasing real wage in adjacent provinces and this could eventually reduce the national fertility rate. However, though negative, the direct effect of real wage on fertility is found to be insignificant. This suggests that provincial real wage plays a marginal role in driving regional fertility decision.

Overall, besides female job participation as well as labour market conditions, housing market exhibits a robust effect on fertility decision. Moreover, the association between regional fertility and these variables is subject to a number of econometric issues, namely heterogeneity, endogeneity and spatial dependence. Expectedly, house price inflation deters fertility although it might induce possible income effect from female homeowners. However, the empirical setup in this study could not control for homeownership given the lack of data. Therefore, complementary studies at more disaggregated level will shed further light on the geospatial dynamics of fertility in relation with housing conditions.

4. Conclusion

This paper uses annual panel data for nine South African provinces from 1998 to 2015 to investigate the housing effect of regional fertility. The analysis focuses on middle housing segments and its subcategories given the availability of regional house price data. When heterogeneity, endogeneity and spatial dependence are controlled for, the empirical results from spatial Durbin model show negative and significant direct and total effects of house prices on regional fertility rate. Consistent across housing categories, these results imply that the increase in provincial house prices will lead to the decline in the local and subsequently national fertility rate. However, the indirect housing effects are positive and significant; suggesting positive spillover effects to adjacent geographical areas following an increase in house prices from a particular region.

Besides housing markets, female labour participation as well as job market conditions appear to play an important role in driving fertility decision. Particularly, the negative and significant direct marginal effects and the positive and significant indirect and net marginal effects, respectively evidence the trade-off as well as the income effects of female job participation on fertility decision. The negative and significant indirect and total marginal effects of real wage on fertility rate indicate that high regional earnings discourage fertility at the national level with spillover effects to adjacent regions. These findings highlight the crucial role of spatiotemporal economic behavior in shaping regional fertility in South Africa. However, the spatial interactions assumed to channel through dependent and independent variables in the SDM may occur through alternative channels such as errors and individual or time heterogeneities. Therefore, our paper offers a benchmark framework against which housing effects of regional fertility from alternative spatial specifications can compare. These can eventually be addressed in future research.

Acknowledgement

The authors are grateful to the associate editor, Prof. Gueorgui I. Kolev and two anonymous referees for their comments and suggestions, which improved the quality of this paper.

The financial support provided by the South African National Research Foundation (Grant No. TTK150707123686) is also gratefully acknowledged.

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Appendix A: South African provincial map

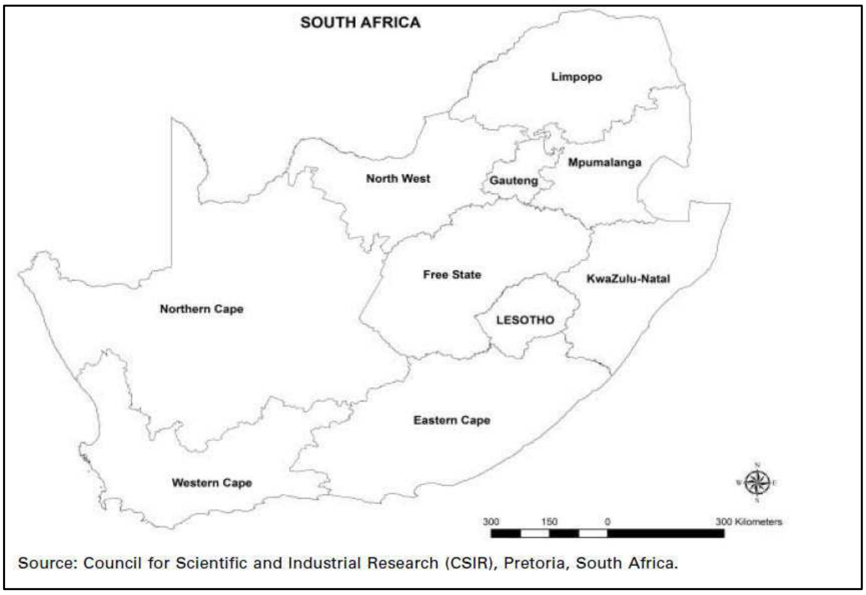

Table 5. First stage RE-SDM estimates explaining real house prices across housing segments

	Total-Middle Housing segment	*Large-Middle Housing segment*	*Medium-Middle Housing segment*	*Small-Middle Housing segment*
Direct effect				
RLR	-2.6094***	-1.5056***	-1.6550***	-1.3836***
FLFP	-0.002	0.8675***	0.7664***	0.6299***
RW	0.3907***	1.6210***	1.6933***	1.5275***
Indirect effect				
RLR	-9.5915***	-4.5505***	-4.4600***	-4.2807***
FLFP	-6.7074***	1.7149**	1.8306***	1.5739**
RW	0.5619	1.6221***	1.4855***	1.4095***
Total effect				
RLR	-12.2009***	-6.0561***	-6.1150***	-5.6643***
FLFP	-6.7094***	2.5824***	2.5962***	2.2039**
RW	0.9526*	3.2431***	3.1788***	2.9370***
R^2	*0.9892*	*0.9822*	*0.9857*	*0.9856*

Note. The table reports the marginal house prices effects of instrument (RLR) and other covariates (FLFP and RW), including both province specific and time dummies. Consistently with the rest of the estimations, the displayed output is from the random effects version of SDM. All the variables are in logarithm form except RLR, which has negative values. *, ** and *** denote significance at the 10%, 5% and 1% significance level, respectively.