Is there a (new) bubble in the US housing market? An empirical specification to identify rational housing bubbles*

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Abstract

For the last two years (2020 and 2021), real home prices have risen enormously in the United States. Indeed, the peak prices of 2021 were even more prominent than those experienced during the last housing bubble, which burst in 2006. Thereby, one relevant question strongly arises: has it emerged a new housing bubble in the US economy? Based on previous academic rational bubble theoretical frameworks and the current account identity, this study demonstrates empirically that such a recent and extreme appreciation trend is not a consequence of a rational housing bubble. Through an OLS panel regression model it is applied an empirical test on three different periods of interest: the Dot-Com Bubble (1996-2000), the Housing Bubble (2002-2006), and the COVID-19 explored episode (2020-2021). From 2020 to 2021 and during the Dot-Com Bubble, an insignificant statistical influence of the US foreign capital inflows is detected on the real house price evolution. While at the same time, in the course of the Housing Bubble, such an effect of the international capital movements on the housing appreciation is statistically significant. Following the previous literature, this empirical evidence identifies the Housing Bubble as the only analysed period containing a rational bubble in the housing market. Consequently, as a result, the Dot-Com Bubble and the years under COVID-19 are not detected as rational housing bubble episodes. This categorisation of the Dot-Com Bubble and the Housing Bubble is consistent with earlier academic research. Hence, the reported novel findings related to 2020 and 2021 are endowed with important credibility since the used empirical strategy can accurately classify prior documented rational bubble events. Moreover, these results exhibit a solid validity after applying several robustness tests. Thus, this analysis offers the first comprehensive empirical evidence postulating that a rational bubble did not emerge in the US housing market during the first two years of the COVID-19 pandemic.

Keywords: Rational Bubbles, Housing Supply Elasticity, COVID-19, Current Account Deficit

JEL classification: E44, F32, R31, E00

1 Introduction

The presence of rational bubbles is one of the current primary debates within the economics and finance literature since remarkable episodes of large and sudden boom-bust cycles in the stock and housing market have occurred in almost all the western countries during the last two decades. Indeed, most of the prior academic research on this topic focused their interest on 2000 and 2006, when in the United States, the two main asset markets experienced significant drops in their value[1]. Nobel Prize Laureates in economics as Tirole (2014), Shiller (2014), and Thaler (2017) but also a

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[1] See Figure 8 for an illustrated image of these mentioned price tendencies of the two main asset markets.

vast number of other academics identify such sharp falls as the burst of the Dot-Com and Housing Bubble, respectively. However, many scholars still related those extreme price trends to changes in the fundamental asset demand and supply. Thereby, there is a current need for studies capable of identifying the existence of rational bubbles to clarify such academic controversy. Thus, this research follows the line of other papers that proposed different empirical approaches to identify rational bubble episodes (e.g. Basco, 2014; Jordà et al., 2015; Giglio et al., 2016) and throw light on this macroeconomic subject. In some way, this study is also related to the empirical work of Glaeser et al. (2008), even if this study analyses irrational (and therefore not rational) asset bubbles.

Observing the aggregate US home market's appreciation trends of recent years, under the COVID-19 pandemic, a noticeably similar scenario is seen as the one experienced during the last documented dwelling rational bubble. Sixteen years after the peak of the Housing Bubble (2002-2006)[2], the average residential real price, measured through the Case-Shiller's house price index, is nowadays in 2022 higher than in 2006. Nonetheless, this significant appreciation was also powerfully relevant in 2020 and 2021. In fact, the annual real home value growth rate in the preceding period was the largest in the last 25 years. According to these facts, a noteworthy question arises: is the United States facing a new rational bubble in their housing market? Some scholars, such as the Nobel Prize winner Krugman (2022), have published some non-academic articles about it[3]. Indeed, the author argued that even if the national residential prices are rising similarly to the last housing bubble, there are significant differences between this historical episode and the latest price enlargements on a local scale. Since by far, the recent regional appreciations are smoother than the peak prices of the mid-2000s. By means of these words, two main ideas can be pointed out. First of all, it is suggested that such a dwelling bubble did not emerge in this economy throughout the recent pandemic. Secondly, it is highlighted that a regional approach is needed to identify the emergence of home market bubbles in the United States. Employing the earlier literature on regional residential bubble analysis (e.g. Glaeser et al., 2008; Mian and Suffi, 2011; Basco, 2014, 2018), this statement made by Krugman can be developed in more detail and be used as a major justification for the local empirical perspective applied in this particular research work.

It is well-known that there are some areas in the US where the housing supply elasticity is significantly less elastic than others. Such house building elasticity can be determined by geographic characteristics (Saiz, 2010) or institutional conditions (Gyourko et al., 2008; Gyourko et al., 2021). Due to these heterogeneity, during the Housing Bubble, there were inelastic regions where the value appreciation shot up to 100% or more, while other areas with an elastic supply "only" rose about a 50%[4]. Thus, the national average increases observed from 2002 to 2006, even being remarkably high, mitigate the unique and astonishing local price tendencies experienced in the Housing Bubble. A clear example of the effects caused by this distortion is witnessed when comparing the local peak house values of the recent years with the ones of the mid-2000s, where it is observed that the new ones are less prominent than those seen in 2006. A central intuition extracted through this simple empirical overview is that the home price increases of 50% or even 70% of the current years can be explained by several assertions that reject the existence of a rational bubble in this market, such as changes in the fundamentals. Those shifts could focus on the fundamental housing supply due to the contemporary national rise in the cost of producer construction materials and amplified through the construction occupation wages increase. In addition, one could claim that such a statement is endowed with a consistent validity since, in 2020 and 2021, the characteristical demand behaviour entailed within the rational housing bubbles (i.e. the generation of an additional significant dwelling demand that previously did not exist) is not observed[5]. On the other hand, it is not reasonable to explain the mid-2000s local dwelling appreciations of more than 100% rather than by a rational housing bubble.

This described situation is plotted in Figure 1. Following the dwelling supply elasticities computed by Saiz (2010), Miami is one of the most inelastic areas, while Dallas is endowed with a remarkable elastic supply. In recent years, there have been similar and smooth value appreciations

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[2] The period definition of the Housing Bubble follows the prior literature on this field (e.g. Basco, 2014, 2018).

[3] See Rana Foroohar (2022) and anonymous authors (2022a, 2022b) for a more extensive example of this described recently academic interest. As one could notice, the cited unknown authors' articles have been published in The Economist, where the article writers are always anonymous.

[4] Indeed, in another non-academic article Krugman (2005) defined the inelastic housing supply US areas as Zoned Zone while the elastic ones as Flatland. This denomination has also been used in academic articles such as in Smith and Smith (2006), Pavlov (2011), and Wisman (2013).

[5] See Figure 8 for a graphical representation of the new privately housing units and the producer price index (PPI) of construction materials' annual evolution.

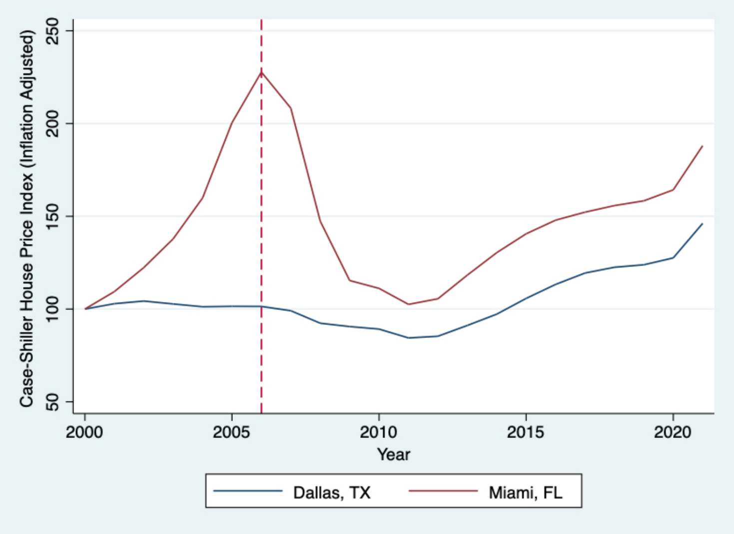

Figure 1: House price evolution for Dallas (TX) and Miami (FL). *Note: The year 2006, defined as the burst of the Housing Bubble, is highlighted with a dotted red line. Case-Shiller's house price index is from FRED, and so the CPI index is used to correct for inflation. In all used variables year 1990 equals 100.*

in both heterogeneous areas, explaining the overall national real home price growth. Nonetheless, such a value increase at a local scale is not even close to the one experienced in 2006 during the Housing Bubble peak. With this example, it is seen how by aggregating both areas, the extraordinary annual appreciation of Miami in the mid-2000s is reduced by the price tendencies of Dallas and not observed in the national growth rates.

Therefore, after reviewing the recent data, the main hypothesis that arises is that in 2020 and 2021, the US experienced an expansion of the supply costs, which consequently raised the real residential prices across the US. This situation described above is crucial since it could partially deny another hypothetical statement claiming that the asset appreciation is not due to shifts in the fundamental supply but demand. Such an idea could be motivated by the enormous national demand stimulus of the American Rescue Plan Act of 2021[6]. Thus, even if these expansionist policies could be the causal explanation of the US real disposable income enlargement (Jordà et al., 2022), it seems that they have not raised the housing fundamental demand since the quantity of newly owned houses is similar to the pre-Housing Bubble periods.

Hence, one could argue which is the point of entering more deeply into such a topic if it seems so clear that there is no rational bubble attached to the US residential market and that all is about the supply-side fundamentals. Regardless, a more accurate approach is needed because some macroeconomic relationships could partially reject the statements obtained by this simple described analysis. That is, by checking the evolution of the US capital inflows and outflows represented by the current national account, or equivalently, through observing the empirical representation of the financial globalisation process (Basco, 2014). In prior literature, this accountability identity is used as a proxy for such an international process representing capital outflows of financially underdeveloped economies going to the developed ones. Indeed, earlier academic investigations found a negative and statistically significant relationship between the current account of the financially developed economies and their real home price expansions only during the presence of rational housing bubbles[7]. The intuition behind such global macroeconomic interaction is straightforward. When the current account deficit of the United States (which could be defined as a financially developed country) increases due to the entrance of foreign capital flows, there is an excess of capital that declines the real interest rate. Consequently, the opportunity cost of purchasing in such an asset market

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[6] The American Rescue Plan Act of 2021 (March 11, 2021), also named the COVID-19 Stimulus Package, was a $1.9 trillion economic stimulus adopted by the 117th United States Congress and inscribed into law by President Joe Biden.

[7] The evidence on a significant relationship between national current account deficit and housing appreciation is largely detected in the literature. Such a negative relationship is discussed in Bernanke (2005) and Caballero et al. (2008). Furthermore, it is also empirically detected across countries (e.g. Aizenman and Jinjarak, 2008; Laibson and Mollerstrom, 2010).

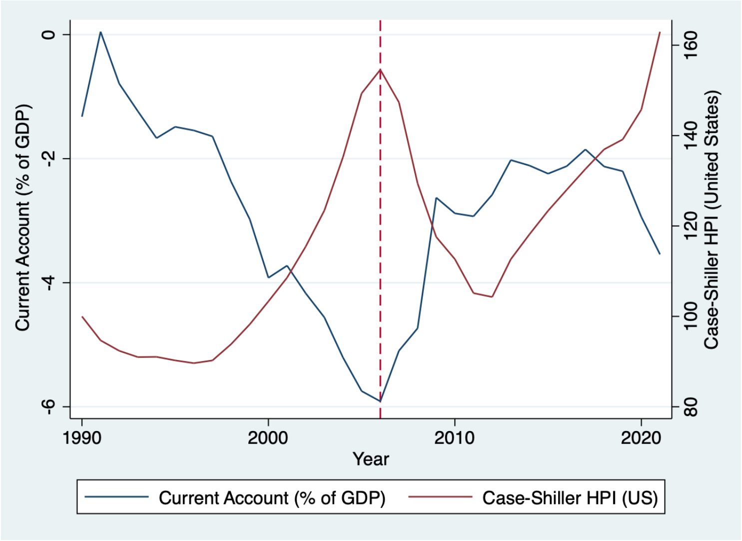

Figure 2: Case-Shiller's house price index and current account in the United States. *Note: It is highlighted with a red dotted line the burst of the Housing Bubble in 2006. The Case-Shiller HPI data is from FRED, and the current account data is from World Development Indicators (World Bank).*

also drops. Moreover, the dwelling demand increases significantly since some agents identify such a scenario as the optimal investment to store their value across time. It is relevant to highlight that these agents do not invest in those housing assets with the willingness to get utility from their direct services but from the storage of value opportunity generated by the bubble. Thereby, during bubble periods, it is experienced an unusual enlargement of the residential demand, which is unrelated to the fundamentals due to the entrance of untypical buyers. Thereby, the entry of foreign capital into financially developed countries increases the likelihood of generating a rational bubble in the housing market, soaring the real home prices due to an unusual expansion of the demand.

This explained relationship between the capital flows and the evolution of the residential market appreciation is empirically illustrated in Fig. 2. It is seen how there was a constant decrease in the current account during the first 26 years of the plotted sample. However, during the Dot-Com Bubble (1996-2000)[8], such capital flows did not increase the housing prices, while during the Housing Bubble (2002-2006) it does. According to that, Basco (2014) defines two different types of rational bubble episodes depending on which asset market is attached (i.e. stock asset market and housing asset market). Meaning, that the association above only takes place when the rational bubble is attached to houses. Thus, one could notice that during the COVID-19, such a central characteristic relationship occurred, which could indicate the presence of a rational housing bubble. Denoting that the demand's enlargement is represented in other variables rather than the prior reviewed newly owned house unit quantity rates. Short speaking, we aim to build an empirical strategy capable of detecting if the negative correlation that is plotted in Fig. 2 during the 2020 and 2021 is statistically significant or not, as it was during the mid-2000s.

Moreover, in Basco, an empirical analysis is proposed where the aforementioned metropolitan housing supply elasticity heterogeneity is considered within the described international macroeconomic association. Indeed, as in Glaeser et al. (2008) the author identifies that such a prior described mechanism intensifies its effect when the supply of assets is more inelastic. When the supply-side reaction is slower, the dwelling appreciation is more prominent since the mismatch between demand and supply is more significant during a more extended time. The author empirically proved this statement using a sample of 138 US metropolitan statistical areas (MSAs) from 1983 to 2007. Thus, our research also studies the statistical significance of such an interaction bearing with the metropolitan dwelling supply elasticities.

Hence, we will apply a robust empirical strategy based on prior regional empirical approaches

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[8] As in the Housing Bubble case the temporal definition of the Dot-Com Bubble is supported by the earlier literature (e.g. Basco, 2014, 2018).

where we aim to detect such a bubble during the latest two entire years under the coronavirus pandemic (i.e. 2020 and 2021) in the United States. Furthermore, to endow our empirical approach with a solid validity, we will analyse two other periods of interest in which the prior literature has documented a rational housing bubble and a non-rational housing bubble. That is, we will study the Dot-Com Bubble and the previously described Housing Bubble. Firstly, we should expect that our model estimates an insignificant statistical relationship between the current account deficit and the real home appreciation during the Dot-Com Bubble while a significant estimation during the mid-2000s. Following the previously described theoretical mechanisms, such outcomes would correctly identify a prior document rational bubble attached to the residential market and suggest that it would be able to detect the existence of other ones. Secondly, through the same process, the COVID-19 episode will be analysed and categorised as a rational housing bubble or not, depending on if the primary interaction is statistically significant. According to the initial hypothesis, we should expect an insignificant estimation. Nonetheless, if, on the other hand, it is significant, it would mean that the relationship plotted in Fig. 2 indicates the emergence of a rational dwelling bubble.

In fact, as the simple Krugman's investigation indicated, our results report that in 2020 and 2021, the financial globalisation process did not cause the emergence of a rational housing bubble in the US. That is, during the COVID-19 analysed episode, it is not detected at a metropolitan scale a statistically significant effect of the triple interaction between the proxy of the financial globalisation process, the real home appreciation, and the housing supply elasticity. In addition, our findings show how this new specification, containing a new time-variant supply-side covariate, successfully replicates Basco's previous results. Noticing that the mid-2000s are detected as a rational housing bubble while, in contrast, the Dot-Com event is not identified as one. Thus, since our empirical approach can correctly detect earlier document housing bubbles, this strategy and the novel results of the analysed coronavirus episode entailed a solid validity.

The last empirical findings of this research reported the outcomes of the robustness tests applied to the previously described results. The empirical conclusions are robust after checking for spatial autocorrelation across metropolitan areas. Moreover, those outcomes are also robust while applying population constraints to delete some MSA that could cause some statistical noise biasing our main results. Furthermore, the obtained outcomes are also consistent by considering another proxy of the financial globalisation evolution that could fit with the theoretical framework that sustains our empirical approach. Then, it is replaced the novel time variant of the residential market supply control variable with a more concrete one, and we obtain a robustness validity again. In addition, another commonly used test, the placebo approach, is also introduced. All those techniques confirm the consistency of the mentioned central results. Thereby, the main contribution of this research is to provide the first robust, comprehensive, empirical analysis of the non-existence of a rational housing bubble during the first years of the COVID-19 pandemic in the US.

It is important to remark that postulating that during 2020 and 2021, there was not a rational housing bubble does not mean that there is no bubble. On the contrary, what is augured is that if a rational bubble exists, it will surely not be attached to the residential market. Since, for instance, there could exist a rational stock market or irrational bubble in the US economy, which indeed is not hard to motivate. Indeed, during the last years, the growth value path of the stock market has also been extremely high, which could indicate the existence of another type of bubble[9]. Of course, it is also possible that any of these bubbles did emerge recently in the United States.

The structure of this manuscript is set as follows. Section 2 reviews the previous literature on rational bubbles, especially Basco's Housing Bubble theoretical model, which is the backbone of this work. In Section 3, the data used in the empirical strategy is defined and supported by illustrated figures such as some maps and tables. Section 4 describes the empirical strategy in detail and the possible endogeneity concerns. Section 5 reports the main results using the benchmark specification. In Section 6, the robustness tests and their outcomes are accurately explained. Section 7, following the results exposed in these sections, builds a novel two-steps housing bubble indicator at a metropolitan scale. Finally, Section 8 contains the conclusions of this research.

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[9] See Fig. 8 in the appendix for a graphical illustration.

2 Literature review

This section will detail the theoretical core of this research work. By this, we mean the classic bubble theoretical model of Basco (2014) and the related previous frameworks to it and the empirical work that surrounded this study[10]. On the one hand, the present analysis can be related to the economic literature on rational bubbles. As it is well-known, the number of academic works in this field is quite extensive. The literature considers seminar Samuelson (1958), Diamond (1965), Blanchard and Watson (1982), Tirole (1982, 1985), and Froot and Obstfeld (1989) as the seminar papers of rational bubbles. Those mentioned works are the core framework of many others which have a well-known impact in the rational bubble thesis (e.g. Santos and Woodford, 1997; Allen and Gale, 2000; Caballero and Krishnamurthy, 2006; Hellwig and Lorenzoni, 2009; Arce and López-Salido, 2011; Martín and Ventura, 2012, 2016; Farhi and Tirole, 2012; Doblas-Madrid, 2012; Giglio and Severo, 2012; Galí, 2014). However, our baseline is Basco's model due to our research purpose, which is also strongly influenced by the previously mentioned seminar papers. This author provides a comprehensive framework that exposes the relations between the international macroeconomic trends and the generation of rational bubbles. Therefore, the thesis of this author allows us to understand the aggregate capital inflows on house appreciation for rational bubbles. The author's approach and its empirical predictions are accurately explained in the following subsections of this part of the manuscript, and such explanations are also complemented with the author's recently published book "*Housing Bubbles: Origins and Consequences*, 2018".

On the other hand, the applied empirical strategy is strongly related to Aizenman and Jinjarak (2009), Case and Shiller (2003), Glaeser et al. (2008), Saiz (2010), and of course Basco (2014). Since, for instance, we will apply the intuitions of Aizenman and Jinjarak about the strong relationship between the national current account deficit and the rise in the housing prices, the empirical findings of Glaeser et al. regarding the housing supply elasticities and the impact effects of the housing bubbles, with the data source of those elasticities provided by Saiz, and of course with the methodological specification of Basco. Moreover, it could also be perceived as a research work related to the academic articles that apply simple econometric tests to identify rational housing bubbles (e.g. Jordà et al., 2015; Gigilio, 2016).

First of all, the conceptual characteristics of the rational bubbles would be defined, and the housing of rational bubbles, which is the type on which we focus more. Then, it will turn on to theoretical frameworks that influenced in a more meaningful manner this study, and finally, the related empirical finds will be exposed.

2.1 Definition of rational bubble and rational housing bubble

Years ago part of the economic academia seemed to resist accepting the idea of asset bubbles. As Caballero (2010) argues, the idea of bubbles belongs to the periphery of the fundamental macroeconomic theory. However, since the last financial crisis of this century, the economic literature has shown enormous interest in rational and irrational bubbles, especially housing bubbles. Nevertheless, as mentioned, some notorious authors studied these phenomena before that historical event when the academia ignored economic bubbles, postulating that there could not exist or could be detected.

The economic literature on this topic defines the historically documented episodes of the Dutch Tulipmania (1636), the South Sea Bubble (1720), the Dot-Com Bubble (2000), and the Housing Bubble (the mid-2000s) as bubble episodes (e.g. Kindleberger, 2000). All these bubble events share common characteristics. First, those incidents began with a demand mania, creating a market disequilibrium between supply and demand. Then, the investors' unexpected "animal spirit" behaviour is turned into a pessimistic feeling about such widely purchased assets, which follows a panic scenario where a massive sales order takes place, driving the bubble to burst and, thus, the price of the prior appreciated asset.

The current economic theory offers two explanations of the origin of these bubbles. The first one is strongly related to behavioural economics. Such perspective is based on the idea that investors start to believe that the return of a particular type of asset would be more prominent in the future for some unexpected reason. This generalised idea generates an "irrational exuberance" in

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[10] As in Giglio et al. (2016) we use the adjective "classic" to describe those models which follow the thesis of Tirole (1985). Other classic bubble models could be those developed in Kocherlakota (2009), Arce and López-Salido (2011), and Miao et al. (2014). However, some scholars define a type of rational bubbles which can be emerged infinite-horizon economies (e.g. Conlon, 2004; Doblas-Madrid, 2016).

this asset market that pushes the price above its fundamental value. On the other hand, another perspective offers a rational view of these events. This rational theory postulates that the origin of asset bubbles is the optimal market response in a scenario with a shortage of assets. This non-behavioural fundamental notion would be the adopted perspective to analyse the selected bubble episodes of interest in this research work. Thus, in the following paragraphs, it will explain the characteristics of these rational theses. However, this does not mean that the author of this study does not recognise the scientific validity of the bubble behavioural thesis. The adoption of the rational perspective is simply that this manuscript aims to know if there existed a rational housing bubble in the US market during the years under the COVID-19 pandemic, not a behavioural one.

According to Basco (2018), by definition, when there is a shortage of assets, it can be postulated that there is a rational bubble. Following this statement, if we define the current national account (CA) level as the result of the demand and supply of assets (i.e. if $CA = Savings - Investments = Demand\,of\,assets - Supply\,of\,assets$) when there is an asset provision smaller relative to its demand (i.e. $Assets\,Supply < Demand\,of\,Assets$) , the resulting negative current account indicates the existence of a rational bubble, by definition. As in every excess of demand, asset prices increase in this situation. However, dissimilar to other common causes of a value appreciation due to a supply shortage, an additional non-fundamental demand strongly increases since some agents identify this scenario as the best opportunity to transfer value to the future, in other words, as the most rational investment. Due to this rational behaviour, the price of the asset bubble will increase since the economic agents see the assets affected by the bubble as a store of value. As a supply-side market response, the following step is an expansion of the asset quantity, which solves the prior shortage. Thereby, through this theoretical perspective, it is understood that a negative current account (or equivalently a positive current account deficit) by definition indicates a shortage of assets that produces a bubble. The market then solves such an asset bubble, adding more assets to it until the economy reaches an equilibrium state. Short-speaking, an asset bubble is the optimal and rational market response to a shortage of assets. This correlation between the countries' capital flows and asset prices has been extensively discussed within the economic literature both empirically (e.g. Aizenman and Jinjarak, 2008; Laibson and Mollerstrom, 2010) and theoretically (e.g. Bernanke, 2005; Caballero et al., 2008).

The primary asset markets are the stock and housing markets. Therefore the rational bubbles can be classified mainly into two groups the Stock-Market Bubbles (e.g. the Dot-Com Bubble, which started in 1996 and burst in 2000) and the Housing Bubbles (e.g. the Subprime Bubble, from 2002 to 2006). Thus, when the rational bubble is attached to the housing asset market (i.e. there is a shortage of houses), an increase in the deficit current account soars the dwelling appreciation. On the other hand, when there is an asset bubble strongly related to the stock market (i.e. there is a sudden increase in the demand for this particular asset), it raises the price value of this asset market. Thereby, conditional on having a rational bubble (i.e. shortage of assets), an increase in globalisation which causes an investment expansion of the developed financial countries (and so an increase of the current deficit account), raises house prices only if the bubble is attached to houses. Furthermore, this effect is more prominent in those areas where the generation of additional assets is more arduous than in others. That is, where the supply elasticity is less elastic and thereby the shortage of assets more difficult to recover.

This process results from the impacts caused mainly by two channels, the reduction of the real interest rate (i.e. the investment opportunity cost) and the subsequent amplification of the asset demand (i.e. the size of the asset bubble). First, to entirely describe this process, we have to define financial globalisation as the continuous worldwide process in which underdeveloped financial economies enter the world capital markets. We also have to assume that the agents of those underdeveloped regions want to access the asset markets of the developed nations since they are considered a better store of value compared to their own countries. Through this assumption, we deduct that an expansion of the globalisation process increases the demand for developed countries' assets (reducing their current account or, on the other way around, increasing the current account deficit of the developed nations), boosting the possibility of having a bubble.

The intuition is not hard to motivate; if financial globalisation increases the foreign demand for the financial developed countries' assets, the likelihood of generating an excess of demand (a shortage of assets) is more considerable. Moreover, due to the arrival of large quantities of investment, the credit cost would decline (i.e. the real interest rate). Thereby, the opportunity cost of investing would also decrease, acquiring assets more attractive. Through a rational behaviour of the agents, the demand for assets will increase in this particular situation, expanding the missmatch between supply and demand, amplifying the prior shortage of asset impact and the size of the asset bubble. In addition, one could argue that the previous positive relationship between current account deficit and asset appreciation is not a direct causal effect. However, it would be indirect since, indeed, only through the real interest rate this impact has a significant effect. Since, through the perspective of this research work, we define a direct causal relationship and not indirect between these two variables, we address and mitigate such potential concerns surrounding the interest rate in the empirical strategy. Nonetheless, as one could notice for this particular study, the causality path is irrelevant since we aim to identify the existence of rational dwelling bubbles, not the causes that originate them.

One advanced insight that can be said about the empirical strategy of this document is the empirical detection of house market bubbles by observing the relationship between house value appreciation of the US metropolitan statistical areas analysed and its supply elasticity level. In a housing bubble, we should expect that those metropolitan areas with less facility to build more houses (generate more assets) would have an enormous effect on the bubble compared to house areas with a more elastic supply elasticity. Moreover, it could be that in those areas with a significant elasticity, the bubble could not have any effect, as shown in prior graph illustrations[11]. On the other hand, if we observe a generalised increase in the house prices no matter the degree of dwelling supply elasticity, it would mean that a bubble does not cause this effect since the cause would not be a shortage of assets.

2.2 A model of rational housing bubbles bearing with financial globalisation

This section will describe Basco's model of the relationship between the financial globalisation process and the emergence of rational housing bubbles more deeply. In this model, the shortage of assets that origins the residential bubbles will arise due to the financial constraints of the agents. This essential idea is not hard to motivate since a vast number of scholars have pointed out these economic boundaries as the causal effect on the bubble generation (e.g. Woodford, 1990; Caballero et al., 2006; Arce and Lopez-Salido[12], 2011; Farhi and Tirole, 2012; Martin and Ventura, 2012). Moreover, several financial constraints exist when borrowing to purchase a house in the real world. An example of that could be the practice of requiring a down payment. Such financial constraints would interact with the arrival of foreign capital during the permanent globalisation process, thereby being conducive to rational dwelling bubbles. Indeed, as one could notice, this subsection will be based on the previous one and will provide a more accurate and technical description of the mentioned concepts. Thus, if the reader understood the prior theoretical subsection and wanted to skip this part, it would not be inconvenient to follow the rest of this research work.

This described model is considered a classic rational bubble framework. That is, it follows the style of Blanchard and Watson (1982) and Tirole (1982, 1985). In the classic perspective, the bubble gains in size (in value) due to the agents' rational expectations. Those expectations aim to resell the assets attached to the bubble at a higher price in the future. As a result of this assumption, the classical bubble thesis can only be sustained on infinite-time asset markets. Basco's three-generation OLG model assumes that each second generation of agents will purchase the dwelling bubble[13] of the prior generation if they know that they will be capable of selling it to the coming one. Thus, such interaction behaves as an infinite-time economy. Thereby, this perspective differs from some models where it is considered a finite-time economy (e.g. Conlon, 2004; Doblas-Madrid, 2016).

Let us consider a three-generation OLG model where the agents live in three periods: young, middle-aged, and old. Those agents get utility from consumption and house services. However, they only consume when they are old and enjoy their residence when they are middle-aged. Meanwhile, they purchase the houses when they are young since it is the moment when they obtain some

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[11] For a complete graphical illustration of this negative relationship between home supply elasticity and house appreciation, see also Figs. 5 and 6 of sections 3 and 5, and in the appendix Fig. 10.

[12] Indeed, Arce and Lopez-Salido's (2011) research work consists of developing a Housing Bubble theoretical approach. This model differs mainly in two aspects from Basco's (2014). First, the agents face heterogenous financial constraints and housing services since it considers the options of renting and buying houses. However, as several times repeated in this study, it is only considered the theoretical approach of Basco.

[13] In Basco's model, it is also assumed that the bubbles could only be attached to the residential market. Unfortunately, no one has developed a model to determine to which market the bubble is attached. Authors have remarked on such indeterminacy as Tirole (1985) and Santos and Woodford (1997).

income and can borrow money. Such simplification is consistent with the empirical evidence of the housing ownership life-cycle, which exhibits an inverse U-shape trend (e.g. Bank et al. 2010). Briefly summarized, this economic life-cycle goes as follows: agents are born at time t and receive an endowment (e.g. income) e, which together with a credit d can buy a house. At the time, $t+1$ when the agents are middle-age, they do not have any income, and so they sell their houses to repay the debt and save a for consumption. Finally, at period $t+2$ agents are old and get utility by consuming their savings returns (i.e. $R_{t+1} \times a$). One could notice that the bubble episode is impossible in this equilibrium setting. That is why the author introduces a borrowing constraint. The idea of a borrowing constraint within the housing market is not hard to motivate since it is a common practice since loan repayment is imperfectly enforceable (making a down payment when borrowing to buy a house is a typical loaning situation).

In Basco, the borrowing constraint is strongly related to the institutional financial quality. Indeed, he postulates a negative relationship between both. When the financial institutions have a good quality (e.g. are more trusty), the enforceability of loan contracts is higher. Consequently, the lender will make a larger loan to the borrower. Thus, the author set a positive relationship between the loan level d, the institutional quality θ, and the relative supply of houses (i.e. investment in building new houses fed with credit). The advanced reader could notice that within a three-generation OLG, there can be generated a parallel bond credit market. Such bonds are collateralized by houses and are the only investment opportunity for middle-aged agents when the economy is not financially developed enough. When the financial institutions are not trusty, there is a shortage of residential assets caused by the small credit available, generating an excess of demand and, thereby, a dwelling bubble. Thus, within an underdeveloped financial economy, the emergence of bubbles in equilibrium is always feasible. However, in developed financial countries where the borrowing constraint is not binding (since the financial institutions have a good quality), the housing bubbles in equilibrium are only possible with the international interaction. The emergence of a bubble is only possible when the entrance of underdeveloped countries expands the initial developed economy's asset demand into their capital market (i.e. through the financial globalisation process).

Let us briefly recall the prior descriptions of the relationship between rational bubble emergence and current account deficit identity could be an ideal initial point.

$$CA = S - I = A - D$$

The current account identity identifies a current account surplus when the savings are more prominent than the investment. To fully understand this situation, let us set two examples. For the first example, consider an economy where local investors are very wealthy (national savings S is relatively higher than I). Since the agents are rational, those wealthy potential investors will first look for investment opportunities in their economy. However, if those opportunities do not exist or there is not enough compared to the capacity to invest, those agents will search for the foreign countries' ideas to invest (e.g. foreign assets). Notice that in this context, the national investors are founding foreign investment. Nonetheless, for the second example, consider a different scenario. Consider an economy where the local entrepreneurs are very successful in providing profitable investment opportunities (e.g. introducing additional units of profitable assets). These agents will look for national investors in the first place. However, if the local investors do not want to find such opportunities, this hypothetical economy's entrepreneurs will search for investors outside their country in international capital markets. As one could notice, in this situation, the aggregate country's level of borrowing will be larger since foreign capital inflows will enter this economy to find the excess investment opportunities without local funding (i.e. $CA < 0$ since $S < I$). Thereby, the current account deficit is related to the net capital inflows. In addition, we can see the national savings S as the demand of assets A, and on the other hand, the national investment I as the supply of assets D.

$$CA = A - D - B \tag{1}$$

Another form to understand the current account is as described above in equation (1). The mismatch between the fundamental demand and supply of assets (i.e. A and D, respectively) is captured by B, the bubble component. The fundamental demand can be understood as the agents[14] willing to purchase a house to enjoy their services. Thus, the size of the bubble will be

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[14] In Basco's model, the fundamental demand is determined by the young agents (first-generation agents) since

defined as $B = A - D$. If the current account is negative, then B will be positive, indicating the emergence of a bubble. The bubble demand component can be seen as the agent's willingness to buy houses to transfer money to the next period in the most optimal manner (i.e. optimal storage of value instrument)[15]. Strictly speaking, we can understand that the author's theory is to highlight the negative relationship between the bubble component B and the current account CA. The model thesis follows the seminar paper of Tirole (1985), explaining the conditions under which rational bubbles can arise in equilibrium. That is, through arbitrage and rationality. Thus, applied to Basco's model, these conditions became:

$$\frac{B_{t+1}}{B_t} \geq R_t \tag{2}$$

$$A_t \geq D_t + B_t \tag{3}$$

Equation (2) represents the arbitrage condition; the agents will only participate in the bubble if the future return on investing in such a phenomenon is more profitable than the current bond return R_t. Remember that since the model considers a three-generation overlapping economy, the model also bears the existence of a parallel bond market that competes with the residential bubble profitability. While equation (3) defines the rationality condition. Meaning that the bubble's size is constrained by the demand for the asset at any point in time. The intuition behind this idea is that there is no possibility of having a supply of assets (including the bubble component) larger than the demand. In other words, the generation of a bubble with a dwelling appreciation that requires a demand greater than the total amount of money in the economy cannot be justified. To sum up, through Tirole's work in Basco's classical model, the only scenario where a rational bubble can emerge in equilibrium is when those conditions are satisfied. That is, when the demand of assets A is bigger than the demand including the bubble (i.e. $D + B$) at a return level of 1 (i.e. $R = 1$)[16].

Let us set the three-period OLG system Basco's approach in detail, which is similar to Laibson and Mollerstrom (2010). However, in this case, the theoretical perspective is not behavioural. It consists of a three periods overlapping generation model, where at time t the economic agents born, they are identical and get utility from consumption c and housing services h. It is relevant to highlight that the three-generation model is only the theoretical story that covers the capital flows of the accountability identity trends. Comprehending that the maximization problem of this hypothetical economy can be set as follows:

$$\begin{aligned} \max \quad & U_t = u(h_{t+1}) + u(c_{t+2}) \\ \text{s.t.} \quad & \left[p_t - (1-\delta)\tfrac{p_{t+1}}{R_t}\right] h_{t+1} + \tfrac{1}{R_t R_{t+1}} c_{t+2} = e \quad (R1) \\ & h_{t+1} \leq \left(\tfrac{1}{1-\theta}\right)\left(\tfrac{e}{p_t}\right) \quad (R2) \end{aligned}$$

Where p_t represents the house asset price at time t, δ the asset depreciation, R_t the current savings return rate, and e an initial endowed income which can be borrowed to purchase a house. We interpret θ as a quality index of the financial institutions. The intuition behind this system is straightforward. In this economy, the agents decide the quantity of housing services they want to enjoy during middle age (at time $t + 1$) and how they want to consume in their old-age (at period $t + 2$). As in several maximization problems, the agents face some constraints. These constraints are represented by equations $R1$ and $R2$. The first one reflects a simple intertemporal budget constraint. The net present value of consumption (including the expenditure on housing services) has to be equal to the net present value of their income (or, equivalently, their initial endowment e).

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they are the ones capable of buying the asset.

[15] Through Basco's premises, the agents that interact with the bubble component are the middle-agents ones (second-generation agents). Thus, the excess demand is created since the number of agents purchasing a house increase significantly. Only the young agents buy houses without a bubble, but middle-aged agents enter the market's demand within a dwelling bubble, raising the prices. Such extra demand is what the author calls the additional housing bubble demand. Thus, if we do not observe a remarkable increase in the house market demand empirically, we can ensure that a housing bubble has not emerged.

[16] For a more detailed explanation see Basco (2014, 2018).

Equation $R2$ defines the borrowing constraint where higher is the institutional quality θ lower is the down payment that agents have to provide, and so more immense the house services (e.g. the size of the house) that can purchase.

Since we define *financial globalisation* as the access of the underdeveloped countries to the world capital market, the next step is to differentiate the developed countries from the underdeveloped. Of course, the differences could imply all the variables of the previous theoretical system; however, to simply and only focus on the financial globalisation, it would be assumed that countries only differ in the quality of the financial institutions (i.e. $\theta^{developed} \equiv \theta^{U} > \theta^{underdeveloped} \equiv \theta^{C}$). In this heterogeneous two-country model it is defined the financial underdeveloped nation as country C, while the financial developed one as country U. Due to the differences in financial institutions, the agents in country U are able to borrow as much as they want (i.e. restriction $R2$ is not binding). On the other hand, the inhabitants of country C since they have underdeveloped institutions they are credit constraint (i.e. restriction $R2$ is binding).

The initial step to describe the trade equilibrium of this economy is to analyse the equilibrium without trade, that is, the autarky equilibrium for each country. The following two equations can reproduce the underdeveloped country's state of equilibrium without trade:

$$A^{C} = a^{C}\left(\theta^{C}, R\right) \tag{4}$$

$$D^{C} = d^{C}\left(\theta^{C}\right) \tag{5}$$

The intuition behind both equations is that the maximization problem of the country's C young agents does not entail any borrowing constraint. Those agents maximize their lifetime utility only limited by the intertemporal budget constraint ($R1$). We could derive the level of dwelling services and consumption through these equations, which maximize the utility. However, for the propose of this research work, we will assume, as in Basco (2018), that those levels are:

$$h^{u}(\delta, R) = \frac{h^{U}(\delta, R)}{N}, \text{ and }, c^{u}(R) = \frac{c^{U}(R)}{N}$$

While operating, we can obtain the optimal saving and borrowing levels of the agents as follows:

$$A^{U} = a^{U}(R) \tag{6}$$

$$D^{U} = d^{U}(\delta, R) \tag{7}$$

The most relevant aspect of these equations is that they do not depend on the interest rate. They do not depend on the savings returns and the opportunity cost of investment. The reason is that once the quality of the institutions is larger than a particular threshold (i.e. when $\theta^{*} < \theta^{U}$), this characteristic becomes irrelevant. The agents of the developed countries do not have any borrowing constraints. Another comment is that $a^{U}(R)$ increases with the interest rate while $d^{U}(R)$ declines. The intuition is evident when the interest rate is low and agents want to consume more in the present rather than in the future. In addition, the supply of assets drops with a higher depreciation rate. This statement can be explained by the idea that when δ rises, so do the user residential costs. This situation impacts the price, and young agents have to choose smaller houses, implying borrowing less. Since Basco defines the supply of assets as the borrowing quantity of the young agents, an increase in the depreciation rate reduces the supply of assets D^{U}.

A relevant aspect to mention is that if the depreciation rate is large enough, it is possible to have rational bubbles in an autarky developed economy[17]. As in the model of Samuelson (1958). To avoid such a potential scenario, it would be assumed that the depreciation rate is low, so that $\delta < \delta^{*}$ where δ^{*} is simply defined by $a^{U}(R = 1) = d^{U}(\delta^{*}, 1)$. This situation implies that autarky developed countries cannot generate rational bubbles since the shortage of assets is not feasible. Moreover, setting this depreciation rate assumption can analyse the trade equilibrium between developed and underdeveloped countries.

In the absence of rational bubbles, the free trade equilibrium of assets can be described with the following market cleaning condition:

$$A^{U} + A^{C} = D^{U} + D^{C}$$

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[17] See Basco (2018) for an accurate description of this statement.

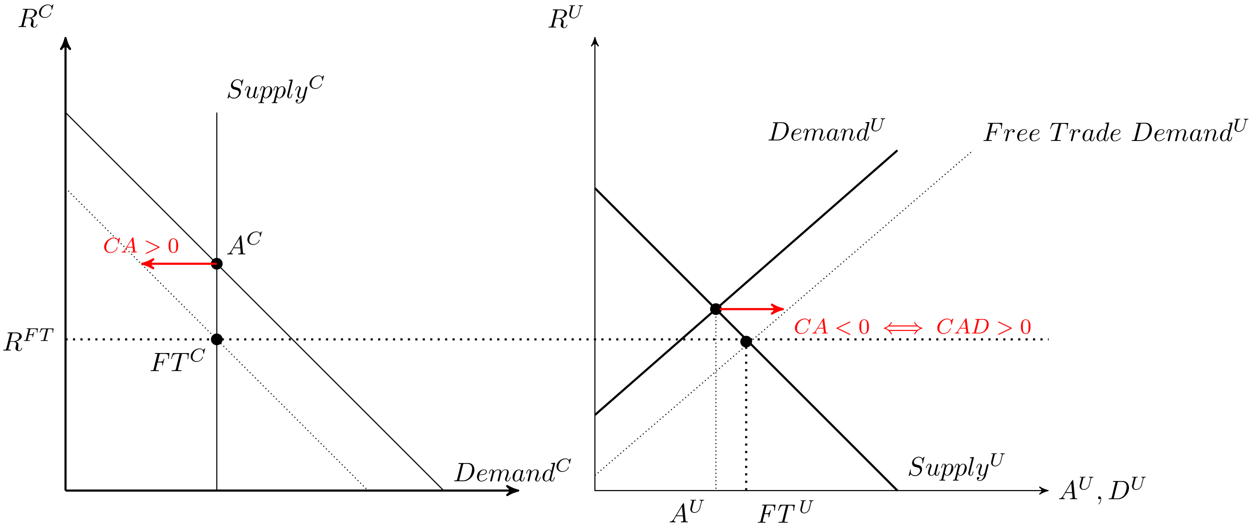

Figure 3: Globalisation and housing bubbles. *Note: The financially underdeveloped country variables (left-hand side of the figure) are defined with an exponent C, while the parameters of the developed country (right-hand side of the figure) with an exponent U. Point FT represents the free trade equilibrium with globalisation. CA represents each country's current account, and CAD their current account deficit. Equations and theoretical mechanisms are discussed in this section.*

The left-hand side of this equation represents the worldwide demand for assets. While the right-hand side, the demand of those. Thus, there exists a unique equilibrium with an equilibrium level interest rate that cleans the global asset market[18]. The other way around, given a particular interest rate level, the global asset market reaches an equilibrium.

Figure 3 describes the global asset market with free trade within the underdeveloped economy (left-hand side) and under the developed country (right-hand side). Point A represents the autarky equilibrium of both economies and FT the free-trade one. As a quick overview, we can see that the autarky equilibrium represents the perfect match between demand and supply of capital in the absence of bubbles.

From now on, we will introduce the possibility of rational bubble emergence within the free trade equilibrium. Then, the bubble size is definition modifies into:

$$B = A^{World}(R = 1) - D^{World}(R = 1) > 0 \tag{8}$$

where,

$$A^{World}(R = 1) = a^u(R = 1) + a^C(\theta^C, 1), \text{ and, } D^{World}(R = 1) = d^U(\delta, 1) + d^C(\theta^C)$$

Equation (8) describes that when $R = 1$ and so there is a shortage of assets, bubbles can be generated under a free trade equilibrium. Following these theoretical mechanisms, a shortage of assets at $R = 1$ since the rational bubble can only rise at the rate of the population label, which the author assumes to be zero.

Intuitively, it can be checked that the undeveloped country requires additional assets since $A^C > D^C$. Moreover, if such excess of demand in the underdeveloped economy is not satisfied with the asset supply of the developed nations, there would be a worldwide shortage of assets (i.e. $D^U > A^U$) and so emerge bubbles in a free-trade equilibrium. After understanding a framework with only two countries, let us a worldwide economy with many countries. In this extended scenario, it would be considered a single financial developed country (e.g. the United States) and a mass of identical underdeveloped nations indexed by i (i.e. $\theta^i = \theta^C\ \forall i$). The only difference between financially underdeveloped economies is that only a fraction of them will join the international capital global market. This fraction of international market expansion will be defined as the financial globalisation process and be represented by τ. Thereby, τ can be seen as a globalisation index since as τ increases, so do the international capital market's members.

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[18] See Basco (2014) for a more detailed explanation of the exact equilibrium conditions.

The next step of this model is to analyse the likelihood of having rational bubbles in the developed country after a rise in the globalisation index[19]. Thus, rational bubbles can only emerge in a developed financial economy under free trade when:

$$B(\tau) = A^U(R=1) + \tau A^C(R=1) - \left[D^U(R=1) + \tau D^C(R=1)\right] > 0 \tag{9}$$

Notice that if $\tau = 1$ equation (9) becomes identical as (8). It can be guessed how globalisation can affect the likelihood of experiencing a rational bubble as higher τ became larger, the possibility of generating an asset bubble. On the other hand, when τ equals zero (i.e. when there is no globalisation process), there is no chance of obtaining a bubble episode in a developed economy. This situation has sense since if there is no globalisation, it means that the developed country forms part of a sort of autarky situation. As explained previously, there is no possibility of having a bubble in this scenario. In addition, it can also be commented that there is the possibility of having an increase in the international capital market (τ^*) which does not create a rational bubble, that is when:

$$B(\tau^*) = 0$$

Thereby, we can conclude that there is a threshold (i.e. $\tau^* > \tau$) where bubbles cannot emerge in equilibrium since the size of the rational bubble will be zero. Moreover, through this framework, we also can understand the relationship between the globalisation index and the size of the asset bubble. Where rearranging equation (9), it can be seen straightforwardly how the increasing number of economies getting access to the international asset markets rises the magnitude of the bubble:

$$B(\tau) = \left[A^U(R=1) - D^U(R=1)\right] + \tau\left[A^C(R=1) - D^C(R=1)\right] \iff B(\tau) = CA^U + \tau CA^C \tag{10}$$

As discussed, following the authors thesis, when $R = 1$ then $CA^U < 0$. However, as also mentioned, when $R = 1$, the underdeveloped countries have a positive net demand for assets. Thus, according to Basco's definitions, it is known that the first term of (10) right-hand side will always be negative and the second term positive. The bubble increases when so does the positive term, which rises with τ. In other words, there is a positive relationship between the globalisation index and the size of the bubble (i.e. $\frac{\partial B(\tau)}{\partial \tau} > 0$).

As mentioned several times previously, this reviewed framework cannot identify which asset market is attached to the rational bubble. Nonetheless, if the bubble is attached to the housing market and assuming that the housing supply is $H^S = h(p) = p^\xi$ (where p are the house prices and ξ the housing supply elasticity), the house appreciation in a developed economy will be described by:

$$p^{Bubble}(\tau) = \left[B(\tau) + D^U(R=1)\right]^{(1+\xi)^{-1}} > \left[D^U(R(\tau))\right]^{(1+\xi)^{-1}} = p^{No-Bubble}(\tau) \tag{11}$$

It is described that the real home price level depends on the size of the bubble $B(\tau)$ (and thereby, on the globalisation index), on the dwelling supply elasticity ξ, and the fundamental demand for houses D^U in the developed country. Notice that the fundamental demand depends on the interest rate. If the interest rate drops, the opportunity cost decreases, making the demand for residential services and, consequently, their price. This negative relationship was explained in the previous lines. Thus, under a rational bubble $R = 1$, we should expect an increase in the fundamental demand for houses in every housing bubble. In every housing bubble episode, demand experienced an additional increase that is not observed in a non-bubble or stock-market bubble. Moreover, it is observed that the more significant the impact of the bubble on the real home value appreciation at more inelastic supply elasticity levels.

2.3 Basco's empirical prediction

Through the previously explained model, it can be subtracted an empirical prediction through the housing bubble theoretical model described above, which is one of the fundamental parts of his

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[19] Recall that in comparison with the financially underdeveloped countries, following Basco's thesis, under an autarky, there is no possibility of having a rational bubble in a developed country. A free-trade scenario is the only potential stage capable of generating asset bubbles in a non-underdeveloped economy.

research work and the core of this study. The author describes this prediction as an extension of the prior theoretical model successfully tested with US metropolitan statistical areas. This relevant prediction is the following:

> *Prediction: Conditional on having a bubble, an increase in globalisation raises house prices only if the bubble is attached to houses. Moreover, this effect is larger, the lower the dwelling supply elasticity is.* (Basco, 2014, pp. 89)

Thus, this subsection will describe an application to the US economy of the last analysed theoretical approach and the rest of the world, the underdeveloped countries. In this case the financial developed country would be the US and the globalisation rate will be positive continuous overtime (i.e. $\tau = \tau(t)$ where t is the year analysed and $\frac{\partial \tau}{\partial t} > 0$). Meaning that the fraction of underdeveloped economies that get access to the international capital market has been rising through the ages. It has been defined as the Dot-Com Bubble from 1996 to 2000, the Housing Bubble from 2002 to 2006, and the COVID-19 episode from 2020 to 2021. Recall that there is a huge consensus in the literature on the mentioned bubbles burst years but some controversy about the initial point of those. We will set our bubble periods definitions based on Basco (2014, 2018).

Through the prior described theoretical model, we can define the used proxy of the globalisation process (i.e. CA and, more accurately, CAD) such as follows:

$$CA^{US}(\tau) = A^{U}(\tau) - \left[D^{U}(\tau) + B(\tau)\right] \iff CAD^{US} = \left[D^{U}(\tau) + B(\tau)\right] - A^{U}(\tau) \tag{12}$$

In the pre-bubble periods (e.g. 1990-1995), there was no bubble in the US, so the globalisation process only impacted the current account by its effect on the interest rate. As shown in figure 4, when the underdeveloped country financially interacts with the developed one, there is a decline in the real interest rate (due to the entry of additional quantities of capital). Since the fall of the interest rate deduces the investment opportunity cost, the supply of assets (D^U) declines relative to the demand of assets (A^U), which increases. Thus, when the current account deficit grows (the globalisation course increases), the mismatch between demand and supply of assets rises since the demand for assets relatively enlarges compared to the supply. Through the model intuitions, we understand that this scenario occurs due to the willingness to purchase US assets of the underdeveloped country's middle-age agents (with the aim of stock value). This relationship is empirically detected, as it is shown in Figure 2.

Moving on to the bubble episodes, bearing with equation (12) it implies that we should expect an increase in the current account deficit (or a decline in the current account) after the start of the Dot-Com Bubble in 1996, and indeed this happens as Figure 2 shows. Applying the reasoning of the author's framework again, we know that this situation takes place because, when there is a bubble, the current account deficit rises since the size of the bubble enlarges with the level of financial globalisation.

The emergence of this second rational bubble shows its peak in 2006 when the current account achieves its minimum level (of the timeline analysed, that is from 1990 to 2021), subsequently in the following years of the burst of this bubble; it is appreciated an increase in the current account which indicates the end of the bubble. That is why, as in Basco (2014, 2018), we define the periods of the Dot-Com and Housing Bubble from 1996 to 2000 and from 2002 to 2006, respectively. Thus, we can ensure that the author's model prediction fits with the US reality. Nonetheless, note that for this simple prediction (i.e. a decline in the current account implies the emergence of a rational bubble), it does not matter which asset markets the bubble is attached to (i.e. housing and stock market).

However, this research work is not analysed an aggregate appreciation of the US asset markets price but the growth of the real home price at a local scale. Thus, to approach this particular study, we extend the model of this mentioned author to a US metropolitan statistical area (MSA) level. That is, to include n areas in the financially developed country (the US). It would be assumed that there is a common labour market and different local housing markets within such a developed country. Following the definitions of the author, the only difference across all the n areas is their dwelling supply elasticity since they have the same level of financial institution (they are financially homogeneous, i.e. $\theta^{n} = \theta^{U} \geq \theta^{*}$).

Recall that we are only interested in financial globalisation's impact on the local house appreciation. Thus, it is essential to theoretically define the steady-state of each developed municipality in the three periods previously analysed; no bubble, Dot-Com Bubble, and Housing Bubble episode. In our particular case, we also will relate the ex-post the results of the COVID-19 episode. Such an event would be compared with the performance of these periods of interest to detect the existence of a residential bubble in the US. By equation (11) it can be defined those periods of interest such as follows:

$$p_n^{No-Bubble}(\tau) = [\sigma_n(R(\tau))]^{(1+\xi_n)^{-1}} \tag{13}$$

$$p_n^{Dot-Com}(\tau) = [\sigma_n(R = 1)]^{(1+\xi_n)^{-1}} \tag{14}$$

$$p_n^{Housing-Bubble}(\tau) = [B_n(\tau) + \sigma_n(R = 1)]^{(1+\xi_n)^{-1}} \tag{15}$$

Where $B_n(\tau)$ represents the size level of the bubble in each area n (in our particular case, in each US MSA), σ_n the fundamental demand of houses for each municipality n, and ξ_n the dwelling supply elasticity of each local area. Following the prior described theoretical mechanisms, by definition, $\sum_n B_n(\tau) = B(\tau)$ where $B(\tau)$ is defined in equation (10) (i.e. $B(\tau) = CA^U + \tau CA^C$).

The intuition behind these equations is straightforward. If there is no bubble, house prices are affected by the financial globalisation course but only through the real interest rate level (i.e. Eq. (13)). In the scenario where there is a rational bubble, but it is not attached to the residential market, as in equation (14) since the interest rate is equal to one house, prices should not be impacted by financial globalisation[20]. Lastly, when there is a housing bubble, there is a house appreciation due to financial globalisation since the size of the bubble increases with this global process (i.e. Eq. (4)).

A more detailed explanation of this intuition is that conditional on having a bubble, the effect of the financial globalisation process has a more substantial effect on real home prices if such a bubble is strongly related to the residential asset market. While, if the bubble is not attached to houses, the increase in foreign capital inflows only sustains the bubble. Thus, in this case, the current account deficit growth does not enlarge the bubble size since it does not raise the dwelling demand. Another relevant characteristic is that such a housing bubble appreciation impact should be more considerable in those places where it is more tricky to add new asset units. That is, in those MSA where the home supply elasticity is more inelastic than in others. This last statement allows us to understand the second sentence of prior mentioned prediction: the housing bubble effect on prices is more significant in those municipalities with a more inelastic supply. This prediction is successfully tested in this research work and the previous literature (e.g. Glaeser et al., 2008; Basco, 2014).

This subsection has described in detail how the main theoretical framework that supports this study provides accurate explanations (which fit with the reality) about the relationship between globalisation and dwelling appreciation at a local scale. Thereby, this thesis would be the backbone of our research work.

2.4 Geographical conditions, housing supply, and housing bubbles

After explaining the theoretical core of this research work which is Basco's theoretical model of housing bubbles, it is relevant to understand the supply side of the residential market. First, acknowledge the Glaeser et al. (2008) simple framework of housing bubbles bearing dwelling supply elasticities. Indeed, the intuition of such a model plays an essential role in the more complex theoretical design of the previously reviewed model. The central intuition of Glaeser et al., which is supported by empirical evidence, is that the areas with more elastic housing supply have fewer and shorter housing bubbles, with smaller house price expansions. Thus, consistent with the urban economics literature presented by Glaeser et al., Basco assumes in his model that the initial local geographic characteristics define the housing supply and, thereby, the response of regional real home value appreciations during the housing bubbles.

Regarding the empirical strategy done by Basco, there is also a strong influence of this literature. Especially in the form of his dependent variable since empirically is not easy to measure the actual size of the housing bubble component. Since within the same region, it could have heterogeneous effects. To mitigate those concerns, the author follows Glaeser et al. and Mian and Suffi (2011), considering the conservative assumption that the annual average size of the bubble can be proxied by the annual average residential appreciation growth rate. Since our research work is based

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[20] Notice that we have assumed that each τ is related to a different steady-state, and we directly switch between those periods of interest.

on Basco, our bubble size proxy variable will also be the annual average price growth at the metropolitan scale.

Indeed there are mainly three significant differences between both articles. First, Glaeser et al. consider the period from 1996 to 2006 as a single rational bubble episode, while Basco divided them into the Dot-Com and Housing Bubble. In addition, the author considers 2001 outside any rational bubble since the current account deficit decreases, indicating the impossibility of holding an asset bubble. The second significant difference is that Glaeser et al. accounts for a time-variant supply-side control variable. Such relevant variable is the construction costs at the MSA scale reported by the private firm RS-Means. The initial aim of this paper was to introduce RS-Means data to Basco's model. However, such an idea was not feasible due to the enormous cost. Nonetheless, the initial aim has been accomplished by searching for an accurate proxy of those time-variant supply costs. The third main difference is that Basco's model is used to detect rational housing bubbles while Glaeser's et al. model is related to non-rational housing bubbles.

2.5 Other empirical studies based on identifying rational housing bubbles

The empirical approach of this research work is related to papers that aimed to detect rational bubbles with a simple econometric framework. For example, Giglio et al. (2016), based on a classic rational bubble theoretical perspective, proposed an empirical test to check if, during a period of boom-bust cycles going from 1995 to 2013, they could detect the housing bubble in the UK and Singapore.

Borio and Lowe (2002), Detken and Smets (2004), and Goodhart and Hofmann (2008) determined the presence of rational bubbles empirically through stabilising a specific threshold relative to a Hodrick-Prescott trend with a high smoothing parameter. Others, instead of focusing on the level deviation, emphasised the growth dynamics of the asset price enlargements. An example of such a perspective is Bordo and Jeanne (2002), where an asset bubble is identified when the 3-year moving average growth rate exceeds by more than 1.3 times the full series standard deviation. Helbling and Terrones (2003), Helbling (2005), and Kose et al. (2008) used other definitions of bubbles but also based on peak-trough changes.

Finally, Jordà et al. (2015) developed an accurate empirical identification of asset bubbles based on a two-step indicator which combines the prior mentioned thesis. The authors propose a cross-country rational bubble indicator that bears significant price deviations from some reference levels and the growth dynamics of the asset value. Indeed, Basco (2018) it is proposed another world home market bubble indicator based on Jordà et al., which simplifies its computational procedures of it. Regarding the resemblances between those mentioned empirical works and this research, Giglio et al. is the one that follows a more similar study line. The econometric presence in both is more extensive than the rest that developed a less statistical approach.

3 Data

To test the prediction of our empirical strategy, it has been considered to analyse a sample of 187 metropolitan statistical areas (MSA) of the US during a timeline of 32 years (from 1990 to 2021). Nonetheless, while some of the previous literature set a population boundary of 500.000 inhabitants (generating a sample of nearly 90 MSAs)[21] in this research work, it has been decided to not apply any of those boundaries in the main results. However, as a robustness test, such population constraints will be applied. Thereby, our primary sample consists of 187 metropolitan areas. Thus, our database is more extensive than the prior analysed samples in central literature on this topic. However, as a robustness test, it has been decided to apply several population-level restrictions to provide results with samples similar to the earlier research works.

The reason for choosing metropolitan areas of the US is not only because this country has suffered in recent years from the mentioned sudden increases in the real home prices rates but because the United States is a big economy (i.e. a so-called "*financially developed country*") that experienced different rational bubbles in the last decades. That is the Dot-Com Bubble and the Housing Bubble. Therefore, this particular country becomes very attractive due to these characteristics since we can test Basco's prediction in two detected rational bubbles and, more

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[21] As in Glaeser et al. (2008) and Saiz (2010).

importantly, with a potential new one. Following the work of this scholar, it has been defined as the Dot-Com Bubble period from 1996 to 2000 and the Housing Bubble episode from 2002 to 2006. Regarding the Dot-Com Bubble, there is a strong consensus that the burst of this bubble was in 2000, and the Housing Bubble definition is consistent with Glaeser's et al. findings. While the COVID-19 episode has been defined in this research work as the period entailing 2020 and 2021. Since the pandemic were reported in China in December of 2019, it was not a worldwide concern until the beginning of 2020. On the other hand, it finished in 2021 only since 2021 is the last year with all the data required in this study. Thus, this period of interest does not define this pandemic's start and end but a pair of chosen years under this worldwide scenario.

Table 1 shows the descriptive statistics of the variables used in metropolitan levels. The house price index at the MSA scale is obtained from the Federal Housing Finance Agency (FHFA). Through this measure, it will be estimated the price evolution of the residential market[22]. However, such an index is computed in nominal terms, and thus it is strongly affected by the US inflation impact providing biased results. Therefore, it has been decided to correct such values with the Bureau of Labour Statistics (BLS) CPI index to obtain an index with real prices. As mentioned in previous sections, it has been decided to use this housing index's annual average price growth rate as a proxy of the annual bubble size[23]. It is also seen how the Housing Bubble episode has a large standard deviation of the real home prices compared with the other periods. This fact is consistent with our previous statements postulating that the smooth appreciations of other areas mitigate the value extreme and unique peaks of this bubble event.

The leading independent variable acts as a proxy of the financial globalisation process. Such variable explained in the previous sections is the current account deficit (CAD) over GDP from International Monetary Fund (IMF)[24]. Recall that in the theoretical part of this document, globalisation has been defined as the entry of foreign capital from an underdeveloped financial country to a developed one (i.e. access to the US asset markets from the rest of the world). Thus, since, as mentioned, we can define the CAD as foreign demand of assets minus national supply of them, the election of this variable is accurate. Indeed, one could claim that the most accurate variable should be the US capital inflows through this theoretical reasoning. For that reason, it would account for these two variables. However, our main proxy will be the CAD data to be consistent with the prior literature, while we will use the adoption of gross capital inflows as a robustness test. The capital inflows data is from the Bureau of Economic Analysis.

To control for the fundamental changes in the dwelling market's value, a set of covariates is introduced. Such is the population growth rate, the MSA's income share, the unemployment rate of each metropolitan area, and the national US real interest rate. First, regarding the controls for the fundamental changes on the demand-side of the residential market, that is population growth rate and income share. The population growth rate data at the MSA scale is from the US Bureau of Economic Analysis (BEA). The metropolitan income share is computed as the personal income share of each MSA divided by the aggregate national personal income share. Both are also from the BEA. On the other hand, the supply-side covariate applied to the unemployment rate at the metropolitan area level is from the Bureau of Labour Statistics (BLS).

To mitigate some concerns about the indirect causal effect from the CAD to the real house appreciation, it is also introduced the real interest rate of the United States. Such variable is defined as the national lending interest rate adjusted for inflation as measured by the GDP deflector and is from the World Development Indicators (World Bank).

The MSAs housing supply elasticity is taken from Saiz's (2010) published and unpublished data[25]. This measure is formed only by geographical and physical characteristics and, therefore, independent of market conditions. Moreover, therefore this particular exogenous physical constraint is preferred to other proxies of the housing marking supply-side conditions. Indeed, some scholars use, instead of the Saiz's elasticity data, the Wharton Residential Land Use Regulatory

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[22] Other related literature used instead of such measure the Case-Shiller Index. Nonetheless, the Case-Shiller index only covers ten MSA from 1987 to 2000 and twenty from 2000 onwards. Thereby, as in the previous literature (e.g. Glaeser et al., 2008; Basco, (2014), it has been decided to use the FHFA's index since we can study an extensive sample and provide a more significant and solid evidence.

[23] As explained this proxy election is to mitigate certain empirical concerns and it is used in other studies (e.g. Glaeser et al., 2008; Mian and Sufi, 2011; Basco, 2014, 2018).

[24] Indeed, through the IMF source, it has been obtained the current account data and then it has been computed the CAD by multiplying such variable by minus one.

[25] The supervisor of this master thesis document, Prof. Sergi Basco, had the kindness to provide to this study the unpublished supply elasticities of Saiz. That is all the elasticities of those metropolitan areas with a population level under 500.000.

	(1)	(2)	(3)	(4)
	All Sample (1990-2021)	Dot-Com Bubble (1996-2000)	Housing Bubble (2002-2006)	COVID-19 Episode (2020-2021)
House Price Index	0.012	0.016	0.048	0.062
(in real terms)	(0.056)	(0.028)	(0.059)	(0.037)
	[0.055]	[0.022]	[0.034]	[0.027]
Supply elasticity	2.198	2.198	2.198	2.198
	(0.998)	(0.998)	(0.998)	(0.999)
	[0.000]	[0.000]	[0.000]	[0.000]
CAD over GDP	2.820	2.491	5.119	3.242
	(1.451)	(0.885)	(0.670)	(0.302)
	[1.451]	[0.885]	[0.670]	[0.302]
Population growth	0.992	1.134	1.067	0.359
	(1.080)	(1.031)	(1.359)	(0.758)
	[0.751]	[0.327]	[0.873]	[0.653]
Income share	0.997	0.899	1.135	1.059
	(0.618)	(0.322)	(0.696)	(0.378)
	[0.585]	[0.220]	[0.572]	[0.357]
Unemployment rate	0.473	0.102	0.417	1.145
	(2.165)	(1.583)	(1.629)	(3.727)
	[1.403]	[0.687]	[0.693]	[3.163]
Real interest rate	-0.115	0.050	0.032	-0.218
	(0.998)	(0.471)	(1.320)	(0.908)
	[0.998]	[0.471]	[1.320]	[0.908]
Observations	5984	935	935	374

Table 1: Descriptive statistics. *Note: Values are annual averages during the periods of interest, with overall standard deviations in parenthesis and within standard deviations in brackets. The House price index is from Federal Housing Finance Agency (FHFA) and corrected by adjusting the inflation impact (i.e. computing the real price). The CPI index used to compute real prices is from the Bureau of Labour Statistics (BLS). Population, income data, and unemployment levels at the metropolitan data scale are from the Bureau of Economic Analysis (BEA).*

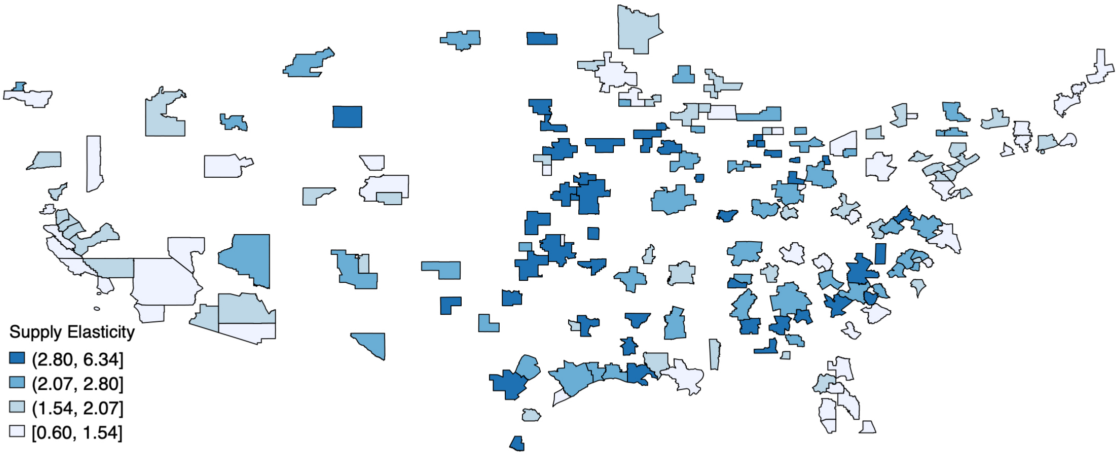

Figure 4: Illustrated map of the 187 US metropolitan statistical areas (MSA) selected in this study, highlighting their housing supply elasticity level. *Note: The darker blue colour corresponds to the more significant housing supply elasticity levels of the sample and, on the other hand, the lighted blue colour the more minor, as the legend of the figure describes. Moreover, it is seen that we do not have a particular spatial clustering of MSAs since they are pretty dispersed. However, a potential uniform distribution of such levels is observed, wherein the west and east cost such magnitudes are lower in comparison with the MSAs which belong to the core of the US (which is expected).*

Index (WELURI) from Gyourko et al. (2008) and Gyourko et al. (2021), which is a measure of the strictness of the local institutional regulatory environment based on an own made survey from 2005 and 2018, respectively, of over 2000 suburban communities across the US. However, since the WELURI index results published in 2008 only cover 47 MSA and 44 MSA for the same index results using the survey from 2018, it would be used as a primary supply-side proxy for Saiz's elasticities (which cover more than 200 US metropolitan statistical areas). In addition, the primary baseline papers of this research work are Basco (2014) and Glaeser et al. (2008). Both also used the Saiz's[26] dwelling elasticities, so the fact of being per such previous literature most substantial this selection. Nonetheless, this elasticity measure has been used in many other papers (e.g. Mian and Sufi, 2011; Chaney et al., 2012). However, to provide a more comprehensive approach to the analysed topic, it is also computed the main specification of this study with the WELURI index data from Gyourko et al. (2021). Nevertheless, as expected, the results were not successful following the previous literature.

Saiz (2010) computed the slope and elevation of every 90 square meter parcel of land for each US metropolitan statistical area through the GIS software. The intuition behind such an aim is that it is more complex to construct a building on land with a slope of 15 degrees or more. This physical characteristic is the primary driver of the computed housing supply elasticities. Thereby, this particular measure is not only exogenous to the economic conditions but also very persistent across time since it is tough to change such geographical conditions over time. Moreover, since the period analysed in this research work contemplates a timeline of 32 years, it has been assumed that this measure is impossible to vary in a statistically significant manner during the analysed years. Figure 4 illustrates the geographical localisation of the 187 MSAs used in the main sample of this study, highlighting their dwelling supply elasticity degree. It is seen that the west and east coast of the US have geographical conditions that generate a less elastic supply elasticity in comparison with the core of the US (which is expected due to the flat and less rugged land conditions of this part of the American country).

Combining the mapping results of Figures 4 and 5, it is seen the negative correlation between home supply elasticity and dwelling price exacerbation straightforwardly during periods of housing bubbles described by Glaeser et al. (2008). It is remarked that during the Housing Bubble, the prices rose in a non-uniform way across the US. Indeed such price increases focus on those parts with a more inelastic dwelling supply elasticity (i.e. East and West US coast). On the other hand,

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[26] The Saiz's home supply elasticity data was published in 2008 in a working paper, this explains why it was used prior to 2010. Nonetheless, the database finally published in 2010 contains some slight differences from the sample of 2008.

during the Dot-Com bubble and the COVID-19 periods, those prices grew uniformly across all United States. Such briefly commented finding that indicates that the COVID-19 event is not a housing bubble episode will be analysed in more detail through the empirical strategy exposed in the next section.

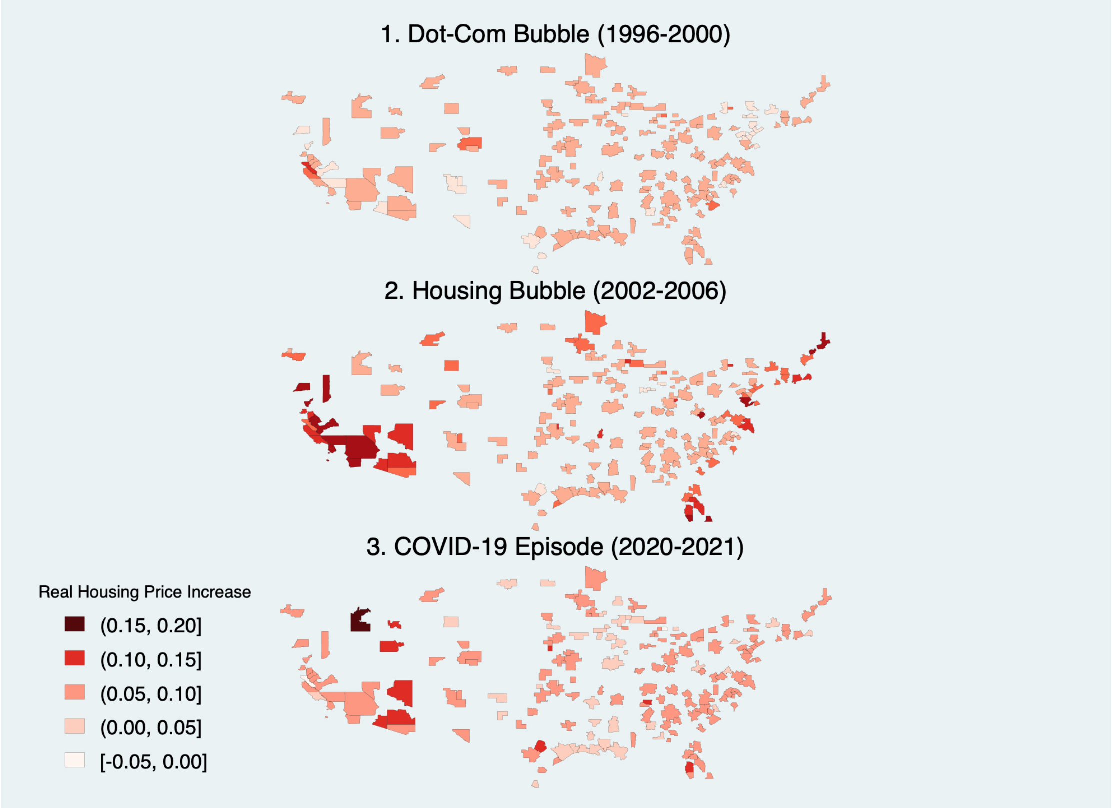

Figure 5: This study selected an illustrated map of the 187 US metropolitan statistical areas (MSA), highlighting their average real home price increase in each episode of interest. *Note: The darker red colour corresponds to the more significant price increase levels of the sample and, on the other hand, the lighted blue colour the more minor, as the legend of the figure describes. Moreover, it is observed that in the Dot-Com Bubble and the COVID-19 episode, the housing price changes follow a more uniform distribution across the different MSAs in comparison with the Housing Bubble. Such plotted results seem to indicate the non-existence of a rational housing bubble in the Dot-Com crises nor the studied COVID-19 episode.*

4 Empirical strategy

As explained in the previous sections, the empirical strategy applied in this research work is strongly influenced by Basco (2014). Thereby, the main econometric specification will follow the same form as his, but in this particular case, we add a new episode of interest (i.e. the COVID-19 episode). Furthermore, we also added a new control variable for the home construction costs since this part of the economy was not fully included in his work. Moreover, as is explained in the following sections, it is also adopted a set of different robustness tests that are not used in such prior literature. Thereby, the reported results are endowed with stronger robustness than the previous ones obtained by the literature for providing a more accurate econometric approach and adding a new potential episode of a rational bubble to test. Under our hypothesis, the COVID-19 analysed period would be theoretically defined as not equal to the Housing Bubble event. Recalling the equations of the prior questions, it would be expressed as follows[27]:

$$p_n^{COVID-19} \neq p_n^{Housing-Bubble}(\tau) = [B_n(\tau) + \sigma_n(R=1)]^{(1+\xi_n)^{-1}}$$

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[27] See section 2.3 in case of willing to understand more deeply its composition and intuition.

The following two-way fixed effect OLS equation will be used to test our central hypothesis about the housing price increases under the COVID-19 episode. It estimates the effects of the independent variables of interest on the changes of the house price index (in real terms) for each US metropolitan statistical area i at every year t.

$$HP_{it} = \alpha + \sum_{j \in \{DB, HB, CB, Rest\,of\,the\,Sample\}} \beta_j \times \frac{CAD_t}{GDP_t} \times elasticity_i \times \rho_j + \phi X_{it} + \delta_i + \gamma_t + \eta_{it} \quad (16)$$

The dependent variable HP_{it} of such specification denotes the real home price index annual changes in real terms[28] and acts as a proxy of the bubble size at the metropolitan area scale. It is applied for different dummy variables ρ_j for the three periods of interest and the rest of the sample. That is, ρ_{DB} is a dummy variable that is equal to one during the Dot-Com Bubble period (1996-2000) and zero otherwise. In the same way, the other variable dummies define the duration of the other periods of interest: ρ_{HB} and ρ_{CB} equal to one during the Housing Bubble (2002-2006) and the COVID-19 analysed episode (2020-2021) respectively, and zero otherwise[29]. Finally, the last dummy variable $\rho_{RestoftheSample}$ only equals one when there is no episode on interest.

Following the description of the first component of equation 16, CAD_t represents the US current account deficit over GDP. In order to apply panel data OLS regressions for each MSA, we need a particular level of CAD_t for each of them. Thereby, we interact this US aggregate variable with the dwelling supply elasticity in a metropolitan statistical area scale. The estimated effect of such described triple interaction for each period of interest is captured by β_j.

The set of used observable control variables is defined by X_{it} and the effect of those by ϕ. These selected variables control for potential effects of the supply and demand side of the residential market, which could bias the results of the estimated triple interaction previously described. It is important to remark that Basco (2014) only controlled for the time-variant demand-side effects[30]. Nonetheless, in this particular research, we also control the build costs and the supply side of the housing market. Thereby, it could be said that the control variables set are improved by adding the intuitions of Glaeser et al. (2008), which intensely studied the effects of the building costs in the housing market.

Concerning the demand side of the market, we control for the personal income share[31] and for the population growth levels of each MSA. Since one could argue that the real home prices in a particular MSA are not growing because the US current account deficit is rising but because the percentage of wealthy people has increased. This claim means that a regional disposable income could boost their willingness to pay and, consequently, the housing assets price. Thereby, controlling for the income share percentage of each metropolitan area, we bear with this potential effect. Moreover, it could also be postulated that dwelling prices could rise due to a particular metropolitan remarkable population growth. Hence, claiming that the supply could be more sticky in some metropolitan areas than its population growth. Nonetheless, this scenario is also taken into mind by controlling the population growth.

Nevertheless, it could be said that the prices are growing not because of some demand aspects but due to the performance of the market's supply side. As an example, from an economic classical school perspective, one could argue that the production costs entailed with this type of asset define, or modifies, the prices and not the market demand[32]. Regarding this concern, the main part of the literature that has the aim to analyse the housing supply characteristics and constraints uses the construction cost data from the R.S. Means Company source database[33]. However, this private database has no open free access, thereby due to this document's characteristics. It has decided not to use this database and search for a helpful proxy[34]. Thus, the applied proxy of the construction cost has been defined as the unemployment rate on a metropolitan scale. The intuition behind this

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[28] Those real prices are computed with the Bureau of Labour Statistics (BLS) CPI index data.

[29] The duration of the Housing Bubble and the Dot-Com bubble has been defined in accordance with the previous literature (e.g. Glaeser et al., 2008; Basco, 2014, 2018)

[30] Notice that the housing supply elasticity only reflects the time-invariant supply-side conditions of the housing market.

[31] The MSA personal income share is computed by diving the personal income of each MSA over the aggregate US personal income. This concrete data is obtained from the Bureau of Economic Analysis (BEA).

[32] See for instance Glaeser et al. (2008, 2018), Gyourko and Molloy (2015) or Hilber and Vermeulen, (2016).

[33] See Somerville, (1999), Gyourko and Saiz (2006) or Glaeser et al. (2008) as an example.

[34] Since this manuscript is a master thesis without any financial support, it has been decided to use an expensive private database in further possible research work with more economic resources.

election is not hard to motivate. If there are unemployed production resources, those costs will decrease, and so will the output prices. Short-speaking, if there is a drop in the unemployment rate, this would indicate that fewer people are unemployed. Therefore, the firms' competition to get workers is more potent (and so is the bargaining power of the workers), and as a consequence, the salaries would rise. Since the wages would increase, so would the production costs and, therefore, the final output price. Thereby, one could argue that the real home prices do not grow due to a more significant level of current account deficit but to the unemployment rate's decline. On the other hand, controlling for the unemployment rate mitigates some concerns about the supply side and demand since less unemployment could cause an expand the dwelling demand.

Finally, we add the interaction of the US real interest rate and the housing supply elasticity to address a potential concern exposed in Basco (2014). The author's point is that it could be augured that the crucial causal relationship between the current account deficit and the real home price performance is not entirely valid. That is that, indeed there is not a direct causal effect from the current account deficit rate to the prices of this asset but an indirect one. Since as it is known there is a strong negative correlation between the current account deficit and the real interest rate. In other words, that the current account deficit has an impact on the residential prices only through the real interest rate. Thereby, to bear with this theoretical statement it is introduced such relevant interaction.

All these described controls are not correlated across them nor across the other dependent and independent variables used in the empirical strategy, as it is shown in the pairwise correlation table (Tables 10 and 11 of the appendix). Moreover, as described in the reported main econometric results, these control variables are endowed with a solid economic and statistical significance in all the cases, indicating their validity and empirical quality. At last, we also control for the time and metropolitan statistical area unobservable characteristics using two fixed effects (i.e. δ_i and γ_t respectively). Indeed, even after applying metropolitan area fixed-effects the correlations across variables are still not significant (see Figs. 12 and 13). Furthermore, of course, α denotes the intercept term, also called the constant term.

4.1 Endogeneity concerns

The previous sections have exposed the theoretical backbone of this study. Through such a theoretical structure, we understand that if there is a unidirectional causal relationship between an expansion of the current account deficit to the analysed asset price. Furthermore, this study is endowed with a solid story that motivates the causal path. Indeed, it has also been mentioned that it could be postulated that such a one-way causal effect is not direct but indirect due to the possible role of the real interest rate. Therefore, the current account deficit only impacts the real home value through the national real interest rate. Nonetheless, as mentioned before, this concern is mitigated within the empirical strategy specification. Indeed, the relationship between the bubble emergence and the current account is an identity which does not depend on Basco's framework. Nevertheless, the author assumes such a causal impact.

However, one could argue a bi-directional causal relationship between the current account deficit and the real housing appreciation. Even so, since the central objective of this study is not to analyse a causal relationship but to test a theoretical prediction, those potential allegations will not be covered in this research work. Moreover, a hypothetical different causal direction would not distort the main results of this research. This research only tests the existence of housing bubble episodes with a simple econometric approach. Thus, whether the current account evolution (i.e. financial globalisation process) drops due to the generation of a rational bubble or the other way around is not relevant for this study.

As one could notice, this non-causal strategy is closely similar to Giglio et al. (2016, 2020), where through residential houses price differences, they create a simple approach capable of detecting rational bubbles in the dwelling market of the UK and Singapore.

5 Results

This section reports the coefficient estimations of equation (16) and the intuitions that we can extract from those. These findings are consistent with our initial hypothesis, which postulated that during the analysed COVID-19 episode (2020-2021), the US economy was not attached to a rational housing bubble. Furthermore, such outcomes have solid credibility since the aforementioned empirical approach correctly identifies prior academically documented rational bubbles attached to the dwelling market. That is, the applied technique indicates that the only period of interest which is a rational home market bubble episode is the Housing Bubble event (2002-2006). Strictly speaking, our model estimates a negative and statistically significant estimation of the primary interaction between the real home appreciation, the financial globalisation process, and the local dwelling supply elasticity only during the mid-2000s (i.e. $\beta_{\text{Housing Bubble}}$). While at the same time, it is estimated a statistically insignificant impact of such interaction during the other periods of interest (i.e. $\beta_{\text{Dot-Com Bubble}}$ and $\beta_{\text{COVID-19 Episode}}$). In addition, it is seen that the estimated effect in the rest of the sample (i.e. $\beta_{\text{Rest of the Sample}}$) is statistically significant and positive. However, the magnitude of the impact is notably smaller than during the mid-2000s. Unfortunately, the literature does not offer a concrete explanation of such a positive and significant influence. Nonetheless, we interpret it as a possible uniform real home appreciation across the US caused by the enlargement of the aggregate investments entailed (i.e. the increase of the current account deficit) by the continuous economic growth that expands the fundamental demand for the asset[35].

5.1 Main results

Fig. 6 plots in a very straightforward manner the essence of our findings obtained through a more accurate method that we will analyse in this subsection and the following ones. It is observed that the more prominent real home appreciations occur during the Housing Bubble and, more specifically, in those metropolitan areas with a less elastic dwelling supply. This non-uniform distribution of the asset appreciation across the different MSAs is captured with the negative slope of the fitted values of this period of interest. Notice that in the other analysed episode of interest, the aforementioned slope is nearly equal to zero. As explained in the sections above, such a slope will always be significantly negative when there is a rational Housing Bubble. Thereby, this subsection can be understood as applying our primary empirical strategy represented with equation 16 to detect the statistical significance of each slope.

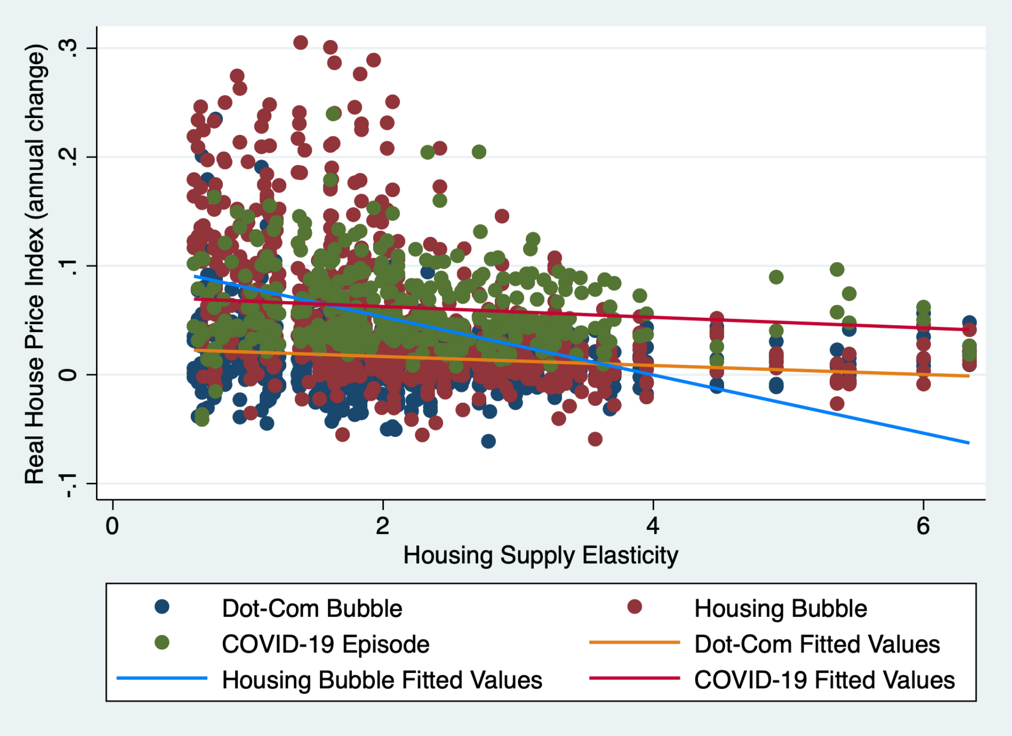

Figure 6: House real value appreciations during the Dot-Com event (1996-2000), the Housing Bubble (2002-2006), and the COVID-19 episode (2020-2021). *Note: House price index at metropolitan statistical area (MSA) level from FHFA and reported housing supply elasticities form Saiz (2010). Real house price index levels are computed correcting by inflation with the CPI index from BLS. The sample consists of 187 MSAs.*

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[35] Basco (2018) partially suggests such intuition..

Table 2 contains the estimations of the coefficient of interest described in the previous sections with robust standard errors clustered by metropolitan areas in parenthesis. Our methodological specification entailed heteroskedasticity and autocorrelation[36]. Therefore, as a standard solution to this problematic situation, it has been decided to provide clustered standard errors. However, it has not been considered to cluster for the time parameter (i.e. years) due to the current ambiguous knowledge of the literature on this point and the potential controversy. Each β_j of the result table represents the estimated coefficient of the triple interaction between the dummy period of interest variable, the current account deficit and the dwelling supply elasticity of each metropolitan statistical area. As observed, the set of observable control variables has been added one by one in this way. Column (4) exactly replicates the variables used (but bearing different periods and an additional episode of interest, the COVID-19 pandemic), and column (5) reports the results adding our new housing market supply-side control.

	Dependent variable: Real House Price Index Annual Growth				
	(1)	(2)	(3)	(4)	(5)
$\beta_{\text{Dot-Com Bubble}}$	-0.0012 (0.0008)	-0.0013 (0.0008)	-0.0005 (0.0008)	-0.0013 (0.0008)	-0.0005 (0.0008)
$\beta_{\text{Housing Bubble}}$	-0.0050*** (0.0007)	-0.0052*** (0.0007)	-0.0048*** (0.0006)	-0.0051*** (0.0007)	-0.0048*** (0.0006)
$\beta_{\text{COVID-19 Episode}}$	0.0003 (0.0007)	0.0002 (0.0006)	-0.0003 (0.0007)	-0.0007 (0.0007)	-0.0011 (0.0007)
$\beta_{\text{Rest of the Sample}}$	0.0024*** (0.0006)	0.0021*** (0.0006)	0.0023*** (0.0006)	0.0018** (0.0006)	0.0020*** (0.0006)
Population growth	0.0175*** (0.0048)	0.0151*** (0.0045)	0.0161*** (0.0045)	0.0154*** (0.0045)	0.0164*** (0.0046)
Income share		0.0131*** (0.0019)	0.0118*** (0.0018)	0.0128*** (0.0019)	0.0115*** (0.0018)
Unemployment rate			-0.0085*** (0.0013)		-0.0084*** (0.0013)
Real interest rate × elasticity				-0.0024*** (0.0005)	-0.0022*** (0.0005)
Constant term	-0.0048 (0.0045)	-0.0142*** (0.0042)	-0.0112** (0.0040)	-0.0139*** (0.0042)	-0.0110** (0.0040)
Observations	5797	5797	5797	5797	5797
R^2	0.502	0.519	0.536	0.521	0.537
adj. R^2	0.482	0.500	0.517	0.502	0.518
$F - test$	17.210***	22.462***	23.823***	19.411***	21.6911***

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 2: Two-way fixed-effect OLS regressions with robust standard errors clustered by metropolitan statistical area in parenthesis. *Note: The sample consist of 187 US metropolitan statistical areas (MSAs) analysed from 1990 to 2021.*

Entering more deeply into the description of our findings, we observe that the interaction coefficients for the Dot-Com Bubble and the COVID-19 episode (i.e. $\beta_{\text{Dot-Com Bubble}}$ and $\beta_{\text{COVID-19 Episode}}$) are not statistically significant in all the cases. On the other hand, no matter which controls we add, the Housing Bubble coefficient is always negative, strongly statistically (at 0,1% level), and

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[36] Such results are obtained through the Breusch-Pagan and Wooldridge tests.

economically significant. Moreover, in the novel specification of this research work, the magnitude of the Housing Bubble interaction (column 5) coefficient slightly declines, indicating that such an effect could be overestimated in the specifications used by Basco (2014). Furthermore, the interaction representing the rest of the sample periods (i.e. $\beta_{\text{Rest of the Sample}}$) presents a positive and very significant value. As explained by Eq. (13), the real home prices are affected by the financial globalisation course but only through the real interest rate performance. In other words, the prices grow due to the fundamental demand increase carried on by the low-interest rates, not through a positive bubble demand component. Thus, such main reported results provide novel findings and theoretical consistency. However, compared with Basco, the magnitude of our estimations nearly doubles them. This result could be due to the fact that the sample analysed in this study is much more extensive[37].

Explaining with more detail the control variables' effects in a first overview, we see that they have the expected signs and that all of them are statistically significant at 0,1% while economically relevant since the magnitude of the estimated impact has some vital effect on the dependent variable (i.e. real real home price index annual growth). Thus, the internal validity of our econometric design is solid. Hence, the degree of confidence about our causal relationship explained previously between the national current account deficit expansion and the house price gains under a housing bubble episode.

As supposed, the population growth level positively affects the real annual home price. It increases demand, creating a temporally excess of demand since the supply is more sticky than other MSAs. As mentioned before, the specification of column (1) ignores the possible scenario wherein particular MSA, the appreciation of the housing assets is rising due to having a personal income increase higher than the average US national income. That is, the wealth of such a hypothetical metropolitan area is increasing above the country's average, and so are the consumer prices, such as dwelling assets. Thereby, column (2) adds MSA's income share rate as a control variable to mitigate such concerns. The only relevant change after such modification is increased the Housing Bubble interaction coefficient since the statistical significance of the estimated parameters of interest remains unchanged. In addition, as expected, the sign of the income share is positive, which supports our intuition about this parameter. Thus, after introducing all the demand side controls, the obtained results have statistical consistency and are theoretical.

In columns (3) and (4), the additional controls are estimated separately before computing all covariates. We also wanted to replicate the exact Basco's specification. This procedure aims not only to have a sanity check of our results but also to analyse the performance of Basco's equation under this novel sample. Thus, starting with column (3) introduces the first time-variant supply-side control variable (i.e. unemployment rate at the MSA scale). As supposed, the sign of the unemployment rate effect on the real home annual appreciation is negative, which has a theoretical sense. Since it can be understood that fewer unemployed workers raise the competition between firms to hire them and so the wages offered to the employees and the cost and the prices of the outcomes (in our specific case, the production of the house costs and sell values). Moreover, such mentioned covariate is statistically significant at 0,1% as the rest of the controls. Therefore, it has a relevant impact on the dependent variable. After adding it, we check that the statistically significant sign of the episodes of interest coefficient remains unmodified, which is another positive outcome following the study's thesis validity. Nonetheless, it is also seen that the magnitude of the Housing Bubble interaction declines, which could indicate that without bearing on the unemployment rate, the computed estimates are overestimated.

Column (4) introduces for the first time the interaction between the US real interest rate to address the mentioned concerns about the potential indirect causal effect of the current account deficit on the housing appreciation. Recall that due to the strong negative relationship between the real interest rate and the current account deficit, one could argue that the rise in the real home prices due to the current account deficit can only happen through the real interest rate effect. Furthermore, it is observed that such interaction is statistically and economically significant. The sign that the estimated effect has theoretical sense since it is not hard to motivate that higher real interest rates to reduce the consumption demand and so the market prices, and the contrary case. Furthermore, the adoption of such interaction increases the magnitude of the estimates of

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[37] In Basco (2014), the database consists of 138 US metropolitan statistical areas and the studied period goes from 1983 to 2007 (25 years). At the same time, the sample of this research work consists of 187 MSAs and a time horizon of 32 years (from 1990 to 2021). Furthermore, Basco reports his results in percentage change instead of differential annual change. As it is evident, the only difference between his and our outcomes reported form of the results is that in our case, the results are not multiplied by 100.

the episodes of interest but not their statistical significance. Therefore, again, the hypothesis of this research work still holds after the adoption of another covariate.

Closing with the analysis of Table 2, column (5) contains the complete set of control variables where it is seen that after the adoption of all of them, the statistical significance and signs of the periods' of interest coefficients still follow the same performance as in the previous cases. Thereby, it can be postulated that we found a shred of solid evidence postulating that during the years 2020 and 2021, there was not a rational bubble attached in the US residential market. However, the size of the Housing Bubble interaction's impact is a bit lower compared to the previous cases. All the controls are statistically significant, and their signs are expected. Thus, this section has provided factual findings that support the idea that in recent years, the US did not generate a rational housing bubble. That is, conditional on having a bubble, an expansion of the current account deficit raises house appreciation only when the rational bubble is attached to the dwelling market. The estimated results of Table 2 emphasise such a thesis since when the current account deficit rises, it has a statistically insignificant effect in the Dot-Com Bubble and COVID-19 analysed periods. On the other hand, when there is an enlargement of the US national deficit during the Housing Bubble period, it has a negative and statistically significant impact.

6 Robustness tests for the obtained estimations

To determine how reliable the previous results are, the following section carries out a variety of robustness tests. Firstly, several population-level constraints will be set to the previously used sample. In a second place, a placebo test adding a non-bubble period. Thirdly, it would be run a regression with additional supply-side time-variant control variables. Then, it would be reviewed the empirical results of equation (16) but using a "Bootstrapping" specification. In a fifth place, Moran's I global spatial auto-correlation test results will be reported. Follwing the Moran's I test, it would be considered a theoretical and empirical robustness test. That is, it would be changed the financial globalisation process proxy variable. One could notice that indeed the theoretical model of Basco defines the globalisation process as the foreign capital inflows coming to the financial developed economy. Thereby, by using the current account deficit which is a net variable (it contains inflows and outflows) could not be theoretically accurate. Thus, it has been substituted the CAD over GDP variable by the US gross foreign inflows over GDP.

All those robustness tests provided successful results regarding the validity of the leading initial findings of this research work. However, it can be shown that following some tests, our results seem overestimated but, at the same time, in others, underestimated. Thus, since our research work does not focus on a detailed description of the magnitudes analysed, we have not entered into much detail on those minor modifications in the existence of housing bubbles. Thereby, through those outcomes, it can be ensured with a shred of solid evidence that any rational bubble emerged in the US home market during the analysed years under COVID-19 pandemic.

6.1 Population-level constraints

It could be said that since most of the previous literature only reports findings of the MSA with a population over 500.000 (e.g. Glaeser et al. 2008, Saiz 2010), the rest of the metropolitan areas are not considered because they generate some sort of bias effect on the estimators. Indeed, as mentioned, the published housing supply elasticities of Saiz are only for those MSAs that satisfy such population-level constraints. Moreover, Glaeser et al. empirical framework also bear this population size boundary based on Saiz's published housing supply elasticities. Thereby, we decided to re-estimate the empirical strategy using equation (16) with five population-level constraints. Such an approach should mitigate those potential concerns about the distorting noise that some of the MSAs considered in the primary sample of this study can cause. In the appendix, Tables 15, 16, 17, and 18 reported the results of adopting population-level restrictions of 100.000, 200.000, 300.000, and 400.000 metropolitan area inhabitants. In all these result tables, the findings of the previous section still hold, without any significant change. The only remarkable aspect of such a test is that we observe that when the boundary level enlarges, the estimated magnitude of the Housing Bubble interaction increases. Such results suggest that our findings are robust and that those effects were underestimated. Table 3 describes the same conclusions.

On the other hand, reviewing Table 3 we detect a decline in the statistical significance of the estimated effect of some controls like the population growth rate and the real interest rate interaction. However, it is not relevant to worry about since the entirely statistical significance of the used controls is not mandatory. Thus, we could conclude that reducing the sample from 187 to 88 MSAs with inhabitants level boundaries provides a solid robustness test to our prior results.

	Dependent variable: Real House Price Index Annual Growth				
	(1)	(2)	(3)	(4)	(5)
$\beta_{\text{Dot-Com Bubble}}$	-0.0027 (0.0015)	-0.0025 (0.0013)	-0.0016 (0.0014)	-0.0025 (0.0014)	-0.0016 (0.0014)
$\beta_{\text{Housing Bubble}}$	-0.0072*** (0.0013)	-0.0074*** (0.0012)	-0.0068*** (0.0012)	-0.0073*** (0.0012)	-0.0067*** (0.0011)
$\beta_{\text{COVID-19 Episode}}$	0.0009 (0.0009)	0.0011 (0.0009)	0.0011 (0.0010)	-0.0000 (0.0010)	0.0001 (0.0010)
$\beta_{\text{Rest of the Sample}}$	0.0029** (0.0008)	0.0026** (0.0008)	0.0029*** (0.0008)	0.0023** (0.0008)	0.0026** (0.0008)
Population growth	0.0145* (0.0065)	0.0121* (0.0060)	0.0130* (0.0060)	0.0124* (0.0060)	0.0132* (0.0061)
Income share		0.0143*** (0.0028)	0.0133*** (0.0026)	0.0139*** (0.0028)	0.0128*** (0.0027)
Unemployment rate			-0.0072*** (0.0011)		-0.0072*** (0.0011)
Real interest rate × elasticity				-0.0027** (0.0009)	-0.0025** (0.0009)
Constant term	-0.0001 (0.0070)	-0.0114 (0.0060)	-0.0057 (0.0058)	-0.0110 (0.0060)	-0.0054 (0.0058)
Observations	2728	2728	2728	2728	2728
R^2	0.599	0.616	0.628	0.618	0.630
adj. R^2	0.580	0.598	0.610	0.599	0.612
$F - test$	15.514***	17.245***	23.342***	14.709***	20.294***

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3: Two-way fixed-effect OLS regressions with robust standard errors clustered by metropolitan statistical area in parenthesis. *Note: The sample consists of 88 US metropolitan statistical areas (MSAs) analysed from 1990 to 2021. Those selected MSAs have an average population from 1990 to 2021 larger than 500.000 inhabitants. The previous literature also uses such applied population-level constraints (e.g. Saiz, 2010).*

6.2 Placebo test

Following the standard robustness tests in the literature, it has been decided to check for a placebo test. We defined another period of interest which should not be a bubble and then computed the main specification to see if it detects such period as a housing bubble or not. If the model defines this placebo episode as a housing bubble, it would mean that our model does not successfully work. Recalling Fig. 2 it is seen how, from 2009 to 2013, the housing price and the current account grew. Thereby, following our research work, since we do not have an increase in the globalisation process, we should not expect a negative sign between the interaction of this period and the current account deficit level. Indeed, we should expect a similar behaviour as the coefficient, representing the rest of the sample. That is, neither a stock market nor a housing bubble.

	Dependent variable: Real House Price Index Annual Growth				
	(1)	(2)	(3)	(4)	(5)
$\beta_{\text{Dot-Com Bubble}}$	-0.0010 (0.0008)	-0.0011 (0.0008)	-0.0004 (0.0008)	-0.0011 (0.0008)	-0.0004 (0.0008)
$\beta_{\text{Housing Bubble}}$	-0.0049*** (0.0007)	-0.0051*** (0.0007)	-0.0048*** (0.0006)	-0.0050*** (0.0007)	-0.0047*** (0.0006)
$\beta_{\text{COVI-19 Episode}}$	0.0005 (0.0007)	0.0004 (0.0006)	-0.0001 (0.0007)	-0.0005 (0.0007)	-0.0010 (0.0007)
$\beta_{\text{Placebo (2009-2013)}}$	0.0043*** (0.0009)	0.0040*** (0.0009)	0.0035*** (0.0009)	0.0036*** (0.0009)	0.0031*** (0.0008)
$\beta_{\text{Rest of the Sample}}$	0.0020** (0.0006)	0.0016** (0.0006)	0.0020*** (0.0006)	0.0014* (0.0006)	0.0018** (0.0006)
Observations	5797	5797	5797	5797	5797
R^2	0.504	0.521	0.536	0.522	0.538
adj. R^2	0.484	0.501	0.518	0.503	0.519

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 4: Two-way fixed-effect OLS regressions with robust standard errors clustered by metropolitan statistical area in parenthesis. *Note: The placebo episode period is defined from 2009 to 2013. The sample consists of 187 US metropolitan statistical areas (MSAs) analysed from 1990 to 2021.*

Table 4 only shows the coefficients of the periods' interactions of interest. The entire results are reported in Table 19 in the appendix. As observed, the placebo episode is not detected as a housing bubble, and thereby we can ensure that the empirical approach is robust. In fact, it is observed that follows a similar trend as the rest of the sample interaction coefficient (i.e. $\beta_{\text{Rest of the Sample}}$). As explained in the previous sections a positive and significant coefficient indicates the non-existence of a housing bubble. The reason of why it is positive as also been explained. That is, the globalisation process proxy interaction has a positive effect in the housing appreciation through the fundamental demand shifts. Recall that, the entrance of underdeveloped economies in the international capital market can affect the housing assets by dropping the real interest rate and so modifying the fundamental demand. However, such a positive impact on housing prices is not caused by the emergence of a bubble (by increasing the bubble component). Moreover, it is also reviewed that the coefficients of the Dot-Com Bubble, Housing Bubble, and the COVID-19 episode remain unchanged. Thus, it proved the validity of the main specification of this study and the prior described results.

6.3 Selecting another time-variant supply-side covariate

One could argue that the unemployment rate is not a good enough control variable to capture the fundamental supply-side changes over time in the housing market. However, it is relevant to recall that this variable has been chosen as an additional proxy for housing production costs. The intuition behind such an election is that a decrease in the unemployment rate indicates a soar supply cost. Reducing those costs should mean an expansion consequently in the house value, which the globalisation process would not cause.

Thus, some concerns could arise about the accuracy of the unemployment rate as the only time-variant control variable of the housing supply phenomenons. Thereby, it has been run an additional panel of regressions using the "Construction and Extraction Occupations" wages reported annually by the Bureau of Labour Statistics (BLS). "Construction and Extraction Occupations"[38] comprises several different occupations. Some of those are first-line supervisors of construction trades, extraction workers, boilermakers, stonemasons, and construction labourers. The CPI from BLS has been used to transform those wages in real terms.

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[38] The BLS identification code for this employment classification is 47-0000.

Nonetheless, the election of this variable has not been the major one since it entails several problems. The major one is regarding the number of periods in which this data is reported; the time horizon of this database is short since those surveys at the MSA level started in 1997. However, the first surveys considering the Construction and extraction occupations' wages were published in 1999. Thus, to apply this variable, it has been needed to redefine the Dot-Com Bubble episode from 1999 to 2000. Secondly, there are many MSAs with missing data during the first reports. Therefore, the final sample used with this new variable reduces the analysed timeline and the number of analysed metropolitan areas.

	Dep. variable: Real HPI Annual Growth	
	(1)	(2)
$\beta_{\text{Dot-Com Bubble}}$	0.0017 (0.0018)	0.0003 (0.0019)
$\beta_{\text{Housing Bubble}}$	-0.0028* (0.0011)	-0.0032** (0.0010)
$\beta_{\text{COVID-19 Episode}}$	0.0037 (0.0024)	0.0005 (0.0021)
$\beta_{\text{Rest of the Sample}}$	0.0056* (0.0022)	0.0043* (0.0020)
...		
Construction wages (in real terms)	0.0000*** (0.0000)	0.0000** (0.0000)
Unemployment rate		-0.0153*** (0.0035)
Observations	1430	1430
R^2	0.600	0.623
Adjusted R^2	0.572	0.596
$F - test$	6.3791***	9.1298***

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 5: Two-way fixed-effect OLS regressions with robust standard errors clustered by metropolitan statistical area in parenthesis. *Note: The sample consists of 65 US metropolitan statistical areas (MSAs) analysed from 1990 to 2021. Those selected MSAs have an average population from 1990 to 2021 larger than 500.000 inhabitants and non-missing values.*

Table 5 is a reduced results table derived from Table 20 reported in the appendix. It is seen that the new covariate is statistically significant but not economically. However, it has an expected sign since higher construction wages should generate larger house prices. On the other hand, the coefficients of interest are not modified, and neither are our main findings. The statistical significance of the Housing Bubble coefficient of interest indeed decreased. This fact also could indicate the lousy performance of the real construction wages as a control variable. Or in the other hand, our previous specification was biased by increasing the statistical significance of those coefficients. However, our primary reported outcomes are still robust since it is still significant.

One could say that this subsection is irrelevant since it is only proved that the real construction wages are not a reasonable control for this approach. Nonetheless, for the author of this manuscript, this section also brings robustness to the main specification of this research since it reviewed the validity of the unemployment rate election as a central covariate. Thus, the concerns about the main econometric equation are mitigated, including those regarding the fundamental role of a superficial variable as it is the unemployment rate.

6.4 Bootstrapping standard error estimations

Analysing the OLS standard conditions of the sample used in this research, it has been detected that some of those are not satisfied. For instance, after computing the Shapiro-Wilk W test for normality of errors (Shapiro and Wilk, 1965), it has been observed that some of the residuals do not satisfy such normal distribution[39]. This situation could generate a biased effect on our prior reported results. Thus a potential technique that allows us to mitigate this problematic situation is re-estimating our previous methodological specification by introducing bootstrapping replications. This particular technique offers a helpful tool for estimating p-values and confidence intervals when OLS standard constraints are not satisfied. Such is the circumstance of this study.

	Dependent variable: Real House Price Index Annual Growth				
	(1)	(2)	(3)	(4)	(5)
Estimations Without Including Bootstrapping					
$\beta_{\text{Dot-Com Bubble}}$	-0.0012 (0.0008)	-0.0013 (0.0008)	-0.0005 (0.0008)	-0.0013 (0.0008)	-0.0005 (0.0008)
$\beta_{\text{Housing Bubble}}$	-0.0050*** (0.0007)	-0.0052*** (0.0007)	-0.0048*** (0.0006)	-0.0051*** (0.0007)	-0.0048*** (0.0006)
$\beta_{\text{COVID-19 Episode}}$	0.0003 (0.0007)	0.0002 (0.0006)	-0.0003 (0.0007)	-0.0007 (0.0007)	-0.0011 (0.0007)
$\beta_{\text{Rest of the Sample}}$	0.0024*** (0.0006)	0.0021*** (0.0006)	0.0023*** (0.0006)	0.0018** (0.0006)	0.0020*** (0.0006)
Estimations Including Bootstrapping					
$\beta_{\text{Dot-Com Bubble}}$	-0.0012 (0.0009)	-0.0013 (0.0008)	-0.0005 (0.0008)	-0.0013 (0.0008)	-0.0005 (0.0008)
$\beta_{\text{Housing Bubble}}$	-0.0050*** (0.0007)	-0.0052*** (0.0007)	-0.0048*** (0.0006)	-0.0051*** (0.0007)	-0.0048*** (0.0006)
$\beta_{\text{COVID-19 Episode}}$	0.0003 (0.0007)	0.0002 (0.0006)	-0.0003 (0.0008)	-0.0007 (0.0007)	-0.0011 (0.0008)
$\beta_{\text{Rest of the Sample}}$	0.0024*** (0.0006)	0.0021*** (0.0006)	0.0023*** (0.0006)	0.0018** (0.0006)	0.0020*** (0.0006)
Observations	5797	5797	5797	5797	5797
$F - test$	17.210***	22.462***	23.823***	19.411***	21.6911***
Wald test (*bootstrapping*)	9542.16***	10950.92***	7675.05***	11410.19***	7740.88***

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 6: Two-way fixed-effect OLS regressions with robust standard errors clustered by metropolitan statistical area in parenthesis. *Note: The last four rows include bootstrapping with 2.000 replications. It has been decided to apply 2.000 replications consistently with the recommendations of Davison and Hinkley (1997). For 95% confidence intervals, the selected number of bootstrapping simulations should be between 1.000 and 2.000. The studied sample consists of 187 US metropolitan statistical areas (MSAs) analysed from 1990 to 2021.*

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[39] As commonly done in the literature, this result has also been revised by graphing the quantile-quantile plot (Q-Q plot).

The main idea of this method is that it is a computer-intensive approach that randomly resamples the original database (either via fitted models or directly) to generate new samples. This simple concept turns out to be a solid solution for many statistical problems. However, it so removes some boundaries that obligate the researchers to oversimply very complex problems (Davison and Hinkley, 1997). As a robustness check, bootstrapping with 2.000 replications has been used to re-estimate the robust standard errors clustered by MSAs and ensure that the statistical significance coefficients of interest remain unchanged. After the bootstrapping estimation, the Dot-Com Bubble and COVID-19 episode effect on the real house value appreciation stand statistically insignificant. At the same time, the interaction estimated of the Housing Bubble remains significant at 0,1%. Therefore, it has been decided to generate 2.000 bootstrap samples following the recommendations postulated in Davison and Hinkley (1997), which argue that the number of replication should be between 1.000 and 2.000 for 95% of confidence intervals.

Table 6 reports the coefficient of interest and the statistical significance of those of Table 2 (the outcomes table of subsection 5.1) and 21 (which is in the appendix and shows the full estimated effects of the OLS regressions with standard bootstrap errors). The dominant conclusion is that the statistical significance of our fundamental conclusion described in the previous sections is robust since it prevails after introducing bootstrapping estimations.

The only slightly remarkable changes appear in the interaction between the elasticity and the current account deficit estimations under the COVID-19 episode. However, the changes in the standard errors are not significant enough to modify the statistical insignificance of this estimation. Thereby, the main findings of this research work can satisfy their validity through another robustness test.

6.5 Checking for spatial autocorrelation

In order to check for spatial correlation within our sample, we will apply the two main used global and local indexes in the economic literature, the Moran's I test (Moran, 1950) in both forms global and local. For the correct understanding of this section's explanation, it is crucial to remember the following punchlines statements done by Pfeiffer et al. (2008) about the difference between global and local spatial autocorrelation:

"A global index of spatial autocorrelation expresses the overall degree of similarity between spatially close regions observed in a given study area A with respect to a numeric variable Y" (Pfeiffer et al. 2008)

In other words, spatial autocorrelation is the correlation across data, strictly due to the relative location proximity of the data objects referred to. Short-speaking measures the correlation between immediate geographical areas. Tobler's (1970) first law of geography arises the fundamental intuition behind this concern:

"Everything is related to everything else, but near things are more related than distant things" pp.235

It would start by checking the global indexes and then the local ones. However, before analysing the reported results, it would be worthy of describing the mechanisms of those tests briefly. The global Moran's I test consists of a null hypothesis which postulates a non-spatial autocorrelation between those the closed regions in area A against a spatial autocorrelation alternative hypothesis. In the particular case of this study, the Moran's I statistic for testing autocorrelation will be defined as follows (results reported in column 2 of Table 7):

$$I = \frac{\sum_{i=1}^{N}\sum_{j=1}^{N}(HP_{it} - \overline{HP_{ijt}})(HP_{jt} - \overline{HP_{ijt}})w_{ij}}{\frac{1}{N}\sum_{i=1}^{N}(HP_{it} - \overline{HP_{ijt}})^2 \sum_{i=1}^{N}\sum_{j=1}^{N} w_{ij}} \tag{17}$$

Where the indexed real house price index appreciation (HP_t) variable represents the value of the variable in the *ith* and *jth* US metropolitan statistical areas (where $i \neq j$) at fixed time t. As commonly write, the upper-bar HP_t represents the average of the variable in year t, and the indexed w's represent the computed spatial weights for all the feasible *ith* and *jth* MSAs couples (where $w_{ii} = 0$).

While, under the null hypothesis of no global spatial autocorrelation, the expected value of the Moran's statistic $E(I)$ is defined as (the computation outcomes are described in column 3 of Table 7):

$$E(I) = -\frac{1}{(N-1)} \tag{18}$$

Indicating that if the Moran's I statistic is greater than its expected value (i.e. $I > E(I)$), there will be suggested a positive correlation with nearby MSAs exhibiting relative values of real house price index annual changes. However, in the contrary case (i.e. $I < E(I)$), a negative correlation will be suggested, with nearby MSAs exhibiting different values of real housing appreciation.

After such a brief explanation, it can proceed to review the results detailed in Table 7. For all the 32 analysed years of our panel data sample, the *p*-values seem to be above the 0.1 and 0.01 threshold, where most of the periods are also above the 0.05 boundary, which means that we could accept the null hypothesis of no global spatial autocorrelation in our sample relaxing the standard confidence levels. However, during the years 1996, 2003, 2005, and 2020 we reject the null hypothesis at 0.5% level, postulating that there is a sort of spatial autocorrelation biasing our main results. Thereby, as Fig. 8 reports, we have computed a spatial fixed effect autoregressive model, which solves the relatively minor spatial autocorrelation issues.

Dep. variable: Real HPI Annual Growth					
(1) Period	(2) *I*	(3) E(I)	(4) sd(I)	(5) z	(6) p-value
year 1990	-0.063	-0.005	0.088	-0.647	0.259
year 1991	0.141	-0.005	0.098	1.487	0.068
year 1992	0.066	-0.005	0.098	0.726	0.234
year 1993	-0.046	-0.005	0.098	-0.418	0.338
year 1994	-0.079	-0.005	0.099	-0.743	0.229
year 1995	-0.138	-0.005	0.099	-1.341	0.090
year 1996	-0.180	-0.005	0.099	-1.771	0.038
year 1997	0.071	-0.005	0.098	0.774	0.219
year 1998	-0.039	-0.005	0.097	-0.348	0.364
year 1999	-0.094	-0.005	0.098	-0.906	0.182
year 2000	-0.059	-0.005	0.097	-0.553	0.290
year 2001	-0.061	-0.005	0.097	-0.575	0.283
year 2002	-0.075	-0.005	0.098	-0.706	0.240
year 2003	-0.182	-0.005	0.098	-1.797	0.036
year 2004	-0.128	-0.005	0.098	-1.245	0.107
year 2005	-0.187	-0.005	0.099	-1.841	0.033
year 2006	-0.096	-0.005	0.099	-0.914	0.180
year 2007	0.033	-0.005	0.098	0.389	0.349
year 2008	-0.054	-0.005	0.098	-0.496	0.310
year 2009	-0.076	-0.005	0.098	-0.717	0.237
year 2010	-0.070	-0.005	0.098	-0.656	0.256
year 2011	-0.069	-0.005	0.099	-0.651	0.258
year 2012	0.018	-0.005	0.098	0.238	0.406
year 2013	0.006	-0.005	0.098	0.115	0.454
year 2014	-0.099	-0.005	0.098	-0.954	0.170
year 2015	0.003	-0.005	0.098	0.086	0.466
year 2016	-0.060	-0.005	0.099	-0.558	0.288
year 2017	-0.154	-0.005	0.099	-1.506	0.066
year 2018	-0.037	-0.005	0.098	-0.321	0.374
year 2019	-0.096	-0.005	0.098	-0.924	0.178
year 2020	0.188	-0.005	0.097	1.986	0.024
year 2021	-0.088	-0.005	0.098	-0.840	0.200

Table 7: Measures of global spatial autocorrelation using the global Moran's I test (1-tail test). *Note: The rows are not standardized. The sample consist of 187 US metropolitan statistical areas.*

	Dependent variable: Real House Price Index Annual Growth				
	(1)	(2)	(3)	(4)	(5)
$\beta_{\text{Dot-Com Bubble}}$	-0.0005 (0.0003)	-0.0003 (0.0003)	-0.0004 (0.0003)	-0.0003 (0.0003)	-0.0004 (0.0003)
$\beta_{\text{Housing Bubble}}$	-0.0008*** (0.0001)	-0.0009*** (0.0001)	-0.0008*** (0.0001)	-0.0009*** (0.0001)	-0.0008*** (0.0001)
$\beta_{\text{COVID-19 Episode}}$	0.0005 (0.0004)	0.0002 (0.0004)	0.0025*** (0.0005)	0.0000 (0.0005)	0.0023*** (0.0005)
$\beta_{\text{Rest of the Sample}}$	0.0012*** (0.0002)	0.0012*** (0.0002)	0.0012*** (0.0002)	0.0011*** (0.0002)	0.0011*** (0.0002)
Population growth	0.0141*** (0.0007)	0.0121*** (0.0007)	0.0128*** (0.0007)	0.0122*** (0.0007)	0.0130*** (0.0007)
Income share		0.0106*** (0.0009)	0.0103*** (0.0009)	0.0103*** (0.0009)	0.0096*** (0.0009)
Unemployment rate			-0.0045*** (0.0004)		-0.0050*** (0.0004)
Real interest rate × elasticity				-0.0004 (0.0002)	-0.0011*** (0.0002)
Weighting Matrix					
Real House Price Index	1.3651*** (0.0181)	1.3667*** (0.0183)	1.3129*** (0.0184)	1.3737*** (0.0188)	1.3288*** (0.0188)
σ_e	0.0381*** (0.0004)	0.0386*** (0.0004)	0.0377*** (0.0004)	0.0381*** (0.0004)	0.0377*** (0.0004)
Observations	5797	5797	5797	5797	5797
Wald test *(of spatial terms)*	5555.37***	5670.31***	5073.54***	5366.93***	4992.81***

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 8: Spatial autoregressive model for panel data with fixed-effects maximum likelihood and the dependent variable spatially lagged. *Note: Robust standard errors in parenthesis. The sample consist of 187 US metropolitan statistical areas during 32 years (from 1990 to 2021).*

The result table above shows that the main conclusions extracted from the prior sections still hold after applying a spatial autoregressive model with the dependent variable spatially lagged (SAR). It is observed how the only period of interest with a negative and significant estimation of the primary interaction is the mid-2000s. Nonetheless, compared to the previous findings, there are slight differences within the unemployment rate specifications. The coronavirus episode is detected as positive and statistically significant in these cases, following the same trends as $\beta_{\text{Rest of the Sample}}$. Such an estimation does not indicate the presence of a rational housing bubble but a potential real home appreciation caused by the enlargement of the fundamental demand. As explained, the literature does not offer an alternative concrete explanation of the interaction's positive and significant estimations. However, in accordance with the prior academic works, it is straightforward that it does not indicate the presence of a rational bubble attached to the home market.

6.6 Introducing a main gross variable on the right-hand side of the empirical specification

This robustness test is not one of the most relevant ones. In fact, it is only addressed to those that could not be fully satisfied with the empirical design strategy due to the chosen financial globalisation process proxy. These potential worries can arise due to the election of the current account deficit as the primary right-hand variable. As it is known that the current account deficit is a net variable since it contains the inflows and outflows of capital. However, capital outflows are not considered in the rational bubble theoretical model used as a backbone of this research. Indeed, in such a model, we only focus on the effect of the new inflows of capital, especially those coming from underdeveloped financial nations that get access to the developed financial countries' asset markets due to the continuous process of globalisation. Thus, the leading independent variable should be a gross parameter that only considers capital inflows. Thereby, it has been consider to mitigate such concerns another time by modifying the main empirical specification of this research work and seeing if the reported results still hold.

$$HP_{it} = \alpha + \sum_{j \in \{DB, HB, CB, Rest\,of\,the\,Sample\}} \beta_j \times \frac{Inflows_t}{GDP_t} \times elasticity_i \times \rho_j + \phi X_{it} + \delta_i + \gamma_t + \eta_{it} \quad (19)$$

As it is seen, in Eq. 19, we substitute national CAD_t over GDP for the aggregate $Inflows_t$ variable divided by GDP. As in prior literature, we have defined the national capital inflows variable as an enlargement in the foreign-owned assets in the US[40]. The outcomes of this modified approach are reported in Table 9 where the main conclusion that it can get is that there is not a significant change that invalidates the previous results of this study. The only coefficient of interest that is negative and statistically significant is the Housing Bubble triple interaction. At the same time, the COVID-19 event remains unchanged despite the last specification, where it is derived a positive and significant coefficient (at 5% level of confidence). However, this result does not indicate a rational bubble in the US house market during the pandemic since it has not a negative sign. What distinguishes it is that it performs similarly to the rest of the sample. As described in Eq. (13) during the non-rational housing bubble episodes, there could be a house appreciation by the impact of the globalisation process. However, such an effect is caused by the real interest rate impact on the asset value. In other words, the housing market value appreciates due to a positive stimulation of the fundamental asset demand done by the interest rate, not through the bubble component. Thus, by applying the complete new specification Eq. (19), it is observed that, indeed, the COVID-19 episode behaves as a non-bubble period. Nonetheless, this evidence is not enough to postulate such a controversial statement. Thereby, as commented several times, we can ensure that there was not a housing bubble during the years under COVID-19 pandemic.

Indeed, it is observed a significant increase in the explanatory power of the three first methodological specifications since the Housing Bubble coefficient nearly doubles in comparison with the reviewed estimations in Table 2. On the other hand, the outcomes of the last two columns have a very similar magnitude compared to the same mentioned results in Table 2.

To sum up, with this robustness test, it can be postulated that the main finding of this research work states that during the years 2020 and 2021, there was no housing bubble in the United States, is robust. Since such evidence still holds, even modifying our primary econometric equation with a more theoretical accurate main independent variable. Thus, until here, the validity of this research findings has been detailed by empirical robustness tests and theoretical mechanisms.

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[40] The data source of US national capital inflows is the Bureau of Economic Analysis (BEA).

	Dependent variable: Real House Price Index Annual Growth				
	(1)	(2)	(3)	(4)	(5)
$\beta_{\text{Dot-Com Bubble}}$	-0.0004	0.0003	0.0022	0.0002	0.0020
(Using net capital inflows)	(0.0018)	(0.0016)	(0.0017)	(0.0016)	(0.0017)
$\beta_{\text{Housing Bubble}}$	-0.0092***	-0.0086***	-0.0085***	-0.0045***	-0.0048***
(Using net capital inflows)	(0.0015)	(0.0015)	(0.0014)	(0.0013)	(0.0012)
$\beta_{\text{COVID-19 Episode}}$	-0.0036	-0.0049	0.0003	0.0047	0.0088*
(Using net capital inflows)	(0.0028)	(0.0028)	(0.0039)	(0.0032)	(0.0039)
$\beta_{\text{Rest of the Sample}}$	0.0006	0.0005	0.0002	0.0021**	0.0016*
(Using net capital inflows)	(0.0006)	(0.0006)	(0.0007)	(0.0007)	(0.0007)
Population growth	0.0173***	0.0149**	0.0161**	0.0152**	0.0163***
	(0.0050)	(0.0048)	(0.0048)	(0.0048)	(0.0048)
Income share		0.0132***	0.0117***	0.0125***	0.0112***
		(0.0019)	(0.0018)	(0.0019)	(0.0018)
Unemployment rate			-0.0093***		-0.0091***
			(0.0014)		(0.0014)
Real interest rate				-0.0043***	-0.0039***
× elasticity				(0.0007)	(0.0006)
Constant term	-0.0067	-0.0177***	-0.0125**	-0.0181***	-0.0129**
	(0.0051)	(0.0045)	(0.0045)	(0.0045)	(0.0045)
Observations	5796	5796	5796	5796	5796
R^2	0.461	0.478	0.498	0.483	0.502
Adjusted R^2	0.440	0.457	0.478	0.462	0.482
$F-test$	20.783***	22.883***	25.667***	19.926***	23.193***

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 9: Two-way fixed-effect OLS regressions using capital inflows with robust standard errors clustered by metropolitan statistical area in parenthesis. *Note: The national capital inflows are defined as an enlarge of the foreign-owned assets in the US. The sample consists of 187 US metropolitan statistical areas (MSAs) analysed from 1990 to 2021.*

7 Two-steps housing bubble indicator

Other academics have identified bubble episodes across countries through the computation of a two-steps indicator (e.g. Jordà et al., 2015; Basco, 2018). Since this method has been proofed as significantly successful, it would also be applied in this research work as a robustness test. The main results of this manuscript, previously described, will be robust if those indicators only detect housing bubbles during the period going from 2002 to 2006. Meanwhile, in all the other years, any housing bubble episode should not be detected since the mentioned empirical results of section 5 show that the Dot-Com Bubble and the years under the COVID-19 pandemic are not consistent with the housing bubble theoretical characteristics.

Following the results of the econometric analysis, this section adapts the steps of the empirical indicators created by Jordà et al. and Basco to fit with the determined housing bubble. The metropolitan bubble indicator indicates the presence of a housing bubble when (i) the annual deviation of the MSA housing prices is above a particular threshold relative to the price trend[41],

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[41] We have defined such threshold as the global price trend standard deviation. It follows the criteria exposed by Basco (2018).

and (ii) house prices fall in the near future. To be more precise, we computed the following regression:

$$House\,Price\,Index_{it} = time + \beta_i + u_{it} \tag{20}$$

The dependent variable of Eq. (20) is the annual average value of the FHFA housing price index for each MSA i at every time t, $time$ equals to the year variable, β_i is the MSA fixed-effect, u_{it} is the residual factor capturing the rest of unobservable characteristics. Then, it has been predicted House Price Index$_{it}$ using the estimates coefficient of the previous OLS panel data regression. Then we define the two indicator conditions as follows:

$$\text{Price Elevation Signal}_{it} = \begin{cases} 1 & \text{if } sd(HP_{it}) < sd(HP_i)\; at\,time\,t \\ 0 & \text{Otherwise} \end{cases} \tag{21}$$

$$\text{Price Correlation Signal}_{it} = \begin{cases} 1 & \text{if } Housing\,Price_{i,t+2} < Housing\,Price_{it} \\ 0 & \text{Otherwise} \end{cases} \tag{22}$$

Hence, the rational housing bubble indicator detects a bubble when both signals equal 1. So, when the indicator is one it detects a housing bubble in the metropolitan area i at year t. That is, when:

$$\text{Housing Bubble Indicator}_{it} = \begin{cases} 1 & \text{if } Price\,Elevation\,Signal_{it} = 1 \quad \& \\ & Price\,Correlation\,Signal_{it} = 1 \\ 0 & \text{Otherwise} \end{cases} \tag{23}$$

The first step is inspired in Borio and Lowe (2002), Detken and Smets (2004), and Goodhart and Hofmann (2008). On the other hand, the second step of the indicator is inspired by Bordo and Jeanne (2002). These mentioned academic articles are described in the literature review section.

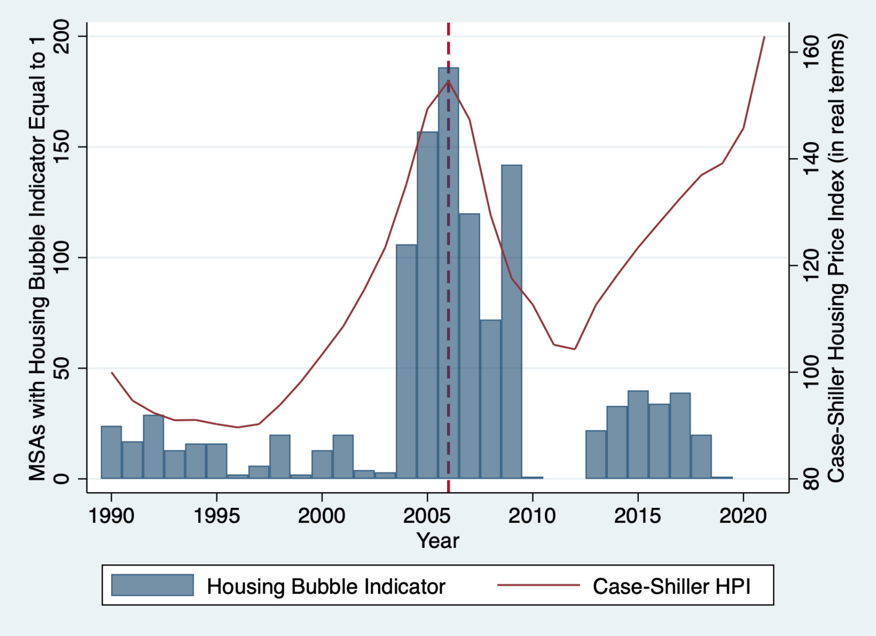

Figure 7: US metropolitan statistical area housing bubble indicators based on Jordà et al. (2015) and Basco (2018) together with the real home price evolution. *Note: The red dotted line highlights the year 2006, which is defined by the previous literature as the burst of the US Housing Bubble. The Case-Shiller index is normalized to 100 in 1990 and corrected by inflation using the CPI index. The sample consists of 187 MSAs with a time horizon of 32 years, from 1990 to 2021.*

Figure 7 report the index's results[42]. It is seen how the year 2006 is the one with a larger number of MSAs with a housing bubble episode is the burst year of the Housing Bubble (i.e. 2006). Such results have theoretical and empirical validity. Moreover, another relevant aspect that is also in accordance with this research work is that the number of MSAs detected with a housing bubble is quasi the majority of the whole analysed sample. Indeed, in the burst of the Housing Bubble, 186 metropolitan areas of the 187 considered in the main dataset are attached to a housing bubble. Thus, this simple indicator inspired in the earlier literature could be used in the future analysis as a basic tool to identify in a simple manner potential housing bubbles. As expected, the results of this described indicator should be complemented with other accurate approaches, as is the case of this study. An example of this aspect is the results reported for 2009, where the indicator identifies a large number of MSAs facing a bubble in the dwelling market. Such empirical outcomes do not follow this study's conclusions or the prior literature.

As one could notice, since this we cannot analyse the COVID-19 event with this index due to the condition reflected in Eq. 22. That is, the dwelling prices at time t are compared with the values of time $t + 2$. Hence, the last two years analysed (i.e. 2020 and 2021) cannot be compared with any future time thereby, and we are not able to see how this index fits with that period of interest. However, since the provided results are feasible with the main results of this research work, we should expect a low number of detected metropolitan housing bubbles using hypothetical data for 2022. This relevant analysed could be done in further research.

In conclusion, using the robust results of this research, a simple two-step housing bubble indicator has been developed at a metropolitan scale that reports feasible results. Therefore, such an indicator could be used as a primary tool to detect easily potential bubbles attached to this asset market.

8 Conclusions

During the first years of the COVID-19 pandemic, the US economy has experienced several different and remarkable impacts in their economy, such as the jobs quit scale record, the S&P 500 historical peak prices, and significant inflation rates. Another astonishing phenomenon during 2020 and 2021 was the unusual soaring of the real house prices that still take place nowadays, in 2022. This considerable increase in the dwelling market value, in aggregate terms, is surprisingly more prominent than the last US recorded rational housing bubble (2002-2006). These extreme value climbs concern the strict absolute magnitude of this asset market and its observed growth rate tendencies. Thereby, one could suppose that the United States faced a new rational bubble in their residential market during those first years of the pandemic. However, in this research work, through a robust, comprehensive empirical analysis supported by a solid theoretical background, it has been shown that such a hypothetical statement is not valid. Following the previous literature on this field, it has been identified that the real housing price trends under the analysed COVID-19 episode (2020-2021) do not fit with the characteristic behaviours entailed within a rational bubble attached to the housing market.

Firstly, the demand for this asset did not reflect an extraordinary spread outside the fundamental average level since the number of newly owned house units was at similar quantities as in the pre-Housing Bubble periods before 2002. Indeed, the US private dwelling demand was significantly more extensive during the Housing Bubble (2002-2006) than in 2020 and 2021. Thus, the expected demand impact that generates a housing bubble (i.e. the expansion of the demand due to the introduction of new buyers that, without a bubble, would not enter into such an asset market) did not occur. Secondly, after testing the empirical prediction of Basco (2014), it has been proved that the COVID-19 event generated tendencies more similar to the Dot-Com stock-market Bubble (1996-2000) rather than the ones of the Housing Bubble.

When a rational bubble is attached to the residential market, the appreciation of this asset is accentuated in those areas with a less elastic dwelling supply. In other words, where the supply-side of the market has more complexities in solving the shortage of houses. Nonetheless, during the COVID-19 pandemic, as in the Dot-Com Bubble, we observed a predominant uniform distribution of the housing price enlargers across almost every US metropolitan statistical area (MSA), which explains the substantial and rare aggregate price levels in the current years. However, at a local scale, during the Housing Bubble, the house appreciation of those areas with a less elastic dwelling

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[42] In Figures 11 and 12 of the appendix it is illustrated two individual representative cases.

supply is by far more prominent than in any other analysed period, even during the COVID-19 pandemic and the Dot-Com Bubble. Indeed, from 2002 to 2006, the value increases of those inelastic areas nearly doubled the growth price magnitudes of most of the COVID-19 observations. The critical intuition that we can obtain from this described situation is that it is feasible to explain a generalised increase of nearly 50% in the dwelling price of most MSAs during the COVID-19 pandemic as a consequence of changes in the fundamental housing demand or supply—and so deny the existence of a rational dwelling bubble during 2020 and 2021. However, it is not convincing to claim the aforementioned assertion, observing the metropolitan price growth rates of more than 100% experienced in the Housing Bubble. The more reasonable justification for such extreme value trends is the emergence of a rational housing bubble. Therefore, even if, in national terms, the price growth rate is more prominent in 2020 and 2021 rather than during the Housing Bubble, the regional value enlargements of the inelastic metropolitan areas are not; indeed, they are significantly lower. Short speaking, the national appreciation tendencies offer a distorted view of the residential real price evolution that can bias our perspective towards the existence of a rational bubble generated in the dwelling market.

Besides, our empirical strategy also reveals the triple interaction between the current account deficit, housing supply elasticity, and the rise of house prices from 2020 to 2021, as in the Dot-Com Bubble, not statistically significant at any confidence level. In contrast, such interaction is substantially statistical significant in the course of the Housing Bubble. This major empirical finding reports that under the COVID-19 and the Dot-Com Bubble episodes, the US economy did not generate a rational housing bubble. At the same time, it identifies the emergence of a rational bubble linked to houses during the Housing Bubble event, which has sense since there is a notable academic consensus about it. Aforesaid central economic relation defines a positive association between the asset value appreciation and the disequilibrium in the residential market due to the entrance of new foreign capital inflows during rational housing bubble periods. This generated capital market mismatch produces an excess of the asset demand that significantly raises the housing price value since the interest rate (i.e. the investment opportunity cost) drops extensively. Rational agents see this situation as the optimal disposable action to store their value across time and, consequently, decide to participate in purchasing the asset bubble. As mentioned, such bubble behaviour enlarges the asset demand even more in areas with inelastic housing supply elasticity. Since as a result, dwelling appreciations and the bubble size are more pronounced due to the complicatedness of relaxing the bubble housing demand by introducing additional asset units.

It is relevant to remark that the prior literature also defines the Dot-Com Bubble as a non-rational housing bubble while the Housing Bubble as one of them. Thus, the validity concerning the empirical outcomes related to the non-existence of a rational housing bubble during COVID-19 is strong since our applied empirical model can classify correctly prior documented rational bubbles. In addition, these exposed empirical results are endowed with solid statistical strength since they have passed several robustness tests. Thereby, we can ensure that during 2020 and 2021, there was no rational housing bubble in the US economy. Moreover, this evidence could suggest that neither currently faces one in 2022. Nonetheless, this statement does not mean that this study refutes the idea of the existence of a rational bubble in the stock market or an irrational bubble in the US economy, which boosted the national housing price growth trends. The presence of these other types of bubbles in the United States is perfectly feasible and could not be hard to motivate. Another hypothetical cause of the housing value tendencies pointed out in this research work could be the observed soar in the supply-chain activities issues caused by the COVID-19 pandemic, mainly represented by the rise of the producers' price index (PPI) of construction materials. This hypothesis is supported by the fact that from 2020 to 2021, the PPI of construction materials was at historical highs. In addition, the increase of other production costs as the national construction and extraction occupation wages could have amplified the consequences of this critical scenario. In other words, the remarkable real dwelling appreciations could result from shifts in the fundamental supply-side components, which grew the production costs of this particular asset considerably. Nevertheless, such a potential hypothesis should be tested and developed in more detail in further research.

In conclusion, the main contribution of this research work is to provide the first comprehensive empirical analysis of the non-existence of a rational housing bubble during the first two years of the COVID-19 pandemic in the US. Furthermore, those reported results are endowed with a solid validity since they successfully passed a considerable number of robustness tests. Moreover, such a novel finding can be understood as a new empirical application of the thesis of Basco (2014).

Appendix

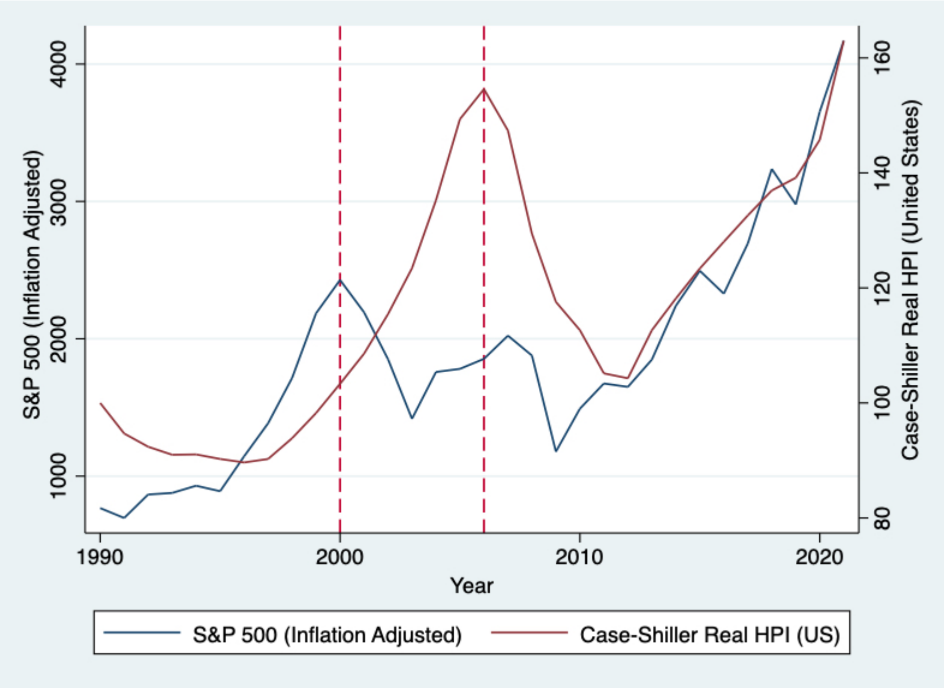

Figure 8: Annual real value appreciation evolution of the two main asset markets. *Note: The highlighted red dotted lines remark the bursts of the Dot-Com Bubble (2000) and the Housing Bubble (2006). The Case-Shiller housing price index is inflation adjusted using the CPI and is from FRED sources (year 1990 is normalized to 100). The SP 500 annual values are from S&P Dow Jones Indices and it is also corrected for inflation using the CPI.*

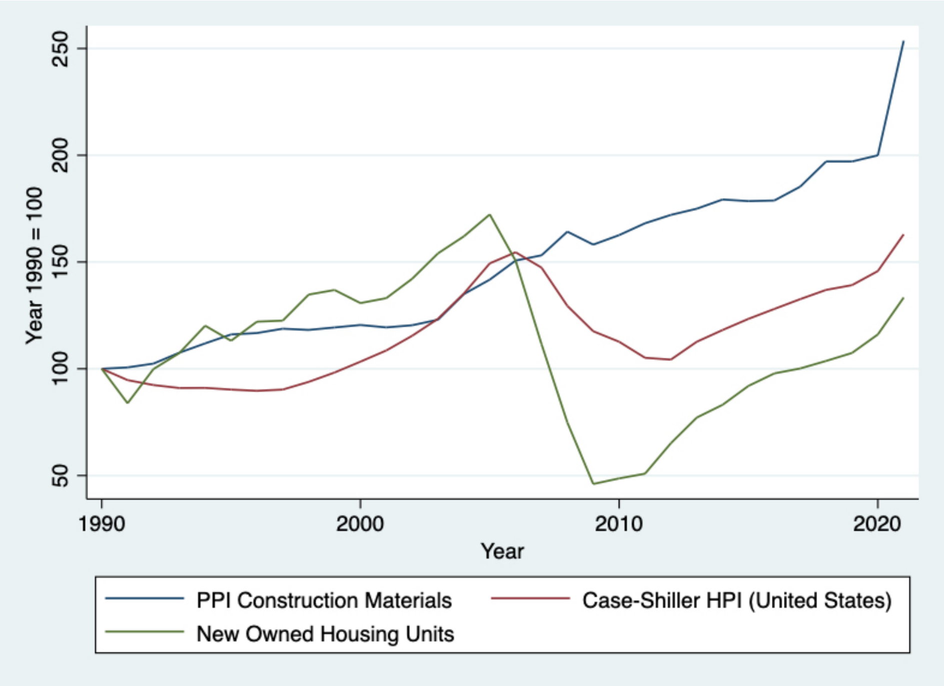

Figure 9: Annual evolution of the producer price index of the construction materials, the housing price index Case-Shiller for the US, and the number of new owned housing units. *Note: The Case-Shiller housing price index is inflation adjusted using the CPI. All data is from FRED sources. Year 1990 is normalized to 100.*

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) House price index	1.000						
(2) Supply elasticity	-0.070	1.000					
(3) CAD over GDP	0.156	-0.000	1.000				
(4) Population growth	0.169	-0.129	-0.039	1.000			
(5) Income share	0.182	-0.060	0.033	0.356	1.000		
(6) Unemployment rate	-0.143	-0.240	-0.014	-0.002	0.013	1.000	
(7) Real interest rate	0.233	0.000	0.036	-0.005	-0.126	-0.269	1.000

Table 10: Pairwise correlations across the variables used in the empirical strategy.

	(1)	(2)	(3)	(4)	(5)	(6)
(1) House price index	1.000					
(2) CAD × elasticity	0.035	1.000				
(3) Real interest rate × elasticity	-0.033	0.301	1.000			
(4) Population growth	0.169	-0.092	0.031	1.000		
(5) Income share	0.182	0.000	-0.044	0.356	1.000	
(6) Unemployment rate	-0.142	-0.151	-0.176	-0.002	0.013	1.000

Table 11: Pairwise correlations across the variables used in the empirical strategy taking into account the interacted terms.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) House price index	1.000						
(2) Supply elasticity	.	.					
(3) CAD over GDP	0.087	.	1.000				
(4) Population growth	0.186	.	0.292	1.000			
(5) Income share	0.170	.	0.126	0.192	1.000		
(6) Unemployment rate	-0.177	.	0.046	-0.005	0.009	1.000	
(7) Real interest rate	0.245	.	0.040	-0.001	-0.161	-0.413	1.000

Table 12: Pairwise correlations across the variables used in the empirical strategy applying MSA fixed-effects. *Note: Housing supply elasticity at the metropolitan scale is a time-invariant variable. Thereby, by introducing fixed-effects, it is cancelled.*

	(1)	(2)	(3)	(4)	(5)	(6)
(1) House price index	1.000					
(2) CAD × elasticity	0.087	1.000				
(3) Real interest rate × elasticity	0.245	0.040	1.000			
(4) Population growth	0.186	0.292	-0.001	1.000		
(5) Income share	0.170	0.126	-0.161	0.192	1.000	
(6) Unemployment rate	-0.177	0.046	-0.413	-0.005	0.009	1.000

Table 13: Pairwise correlations across the variables used in the empirical strategy applying MSA fixed-effects.

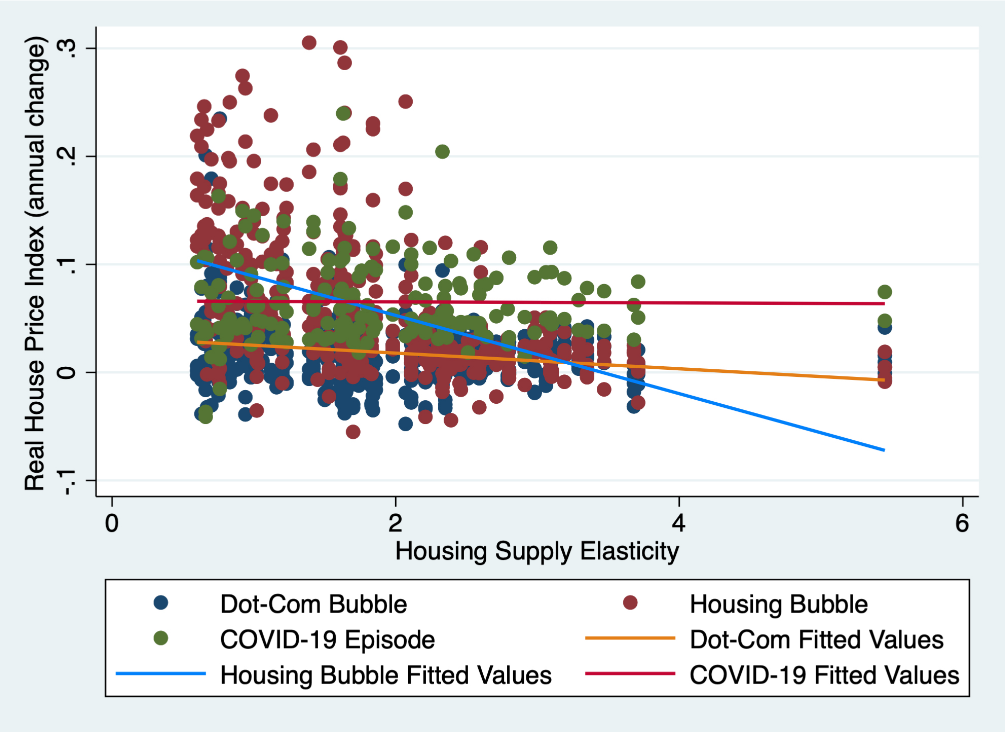

Figure 10: House price appreciations during the Dot-Com event (1996-2000), the Housing Bubble (2002-2006), and the COVID-19 episode (2020-2021). *Note: House price index at metropolitan statistical area (MSA) level from FHFA and reported housing supply elasticities form Saiz (2010). Real house price index levels are computed through correcting by inflation with the CPI index from BLS. The sample consist of 88 US MSAs. Those selected MSAs have an average population from 1990 to 2021 larger than 500.000 inhabitants. Such applied population-level constraint is also used in the previous literature (e.g. Saiz, 2010) MSAs.*

MSA	Supply elasticity
Top 10 least elastic housing supply MSAs	
Alexandria, LA	6.34
St. Joseph, MO-KS	6.00
Wichita, KS	5.45
Fort Wayne, IN	5.36
Longview, TX	3.90
Dayton-Kettering, OH	3.71
McAllen-Edinburg-Mission, TX	3.68
South Bend-Mishawaka, IN-MI	3.64
Lafayette, LA	3.63
Omaha-Council Bluffs, NE-IA	3.47
Top 10 least elastic housing supply MSAs	
Miami-Miami Beach-Kendall, FL	0.60
Los Angeles-Long Beach-Glendale, CA	0.63
Fort Lauderdale-Pompano Beach-Sunrise, FL	0.65
San Francisco-San Mateo-Redwood City, CA	0.66
San Diego-Chula Vista-Carlsbad, CA	0.67
Oakland-Berkeley-Livermore, CA	0.70
Oxnard-Thousand Oaks-Ventura, CA	0.75
Salt Lake City, UT	0.75
New York-Jersey City-White Plains, NY-NJ	0.76
San Jose-Sunnyvale-Santa Clara, CA	0.76

Table 14: List of metropolitan statistical areas with the least and most elastic housing supply included in the research work database. *Note: The reported supply elasticities are estimated in Saiz (2010), however some of them are not published (Saiz only published the elasticities of those MSA with a population level larger than 500.000 inhabitants). Nonetheless, Prof. Sergi Basco PhD who has a larger database with those unpublished housing supply elasticities estimated by Saiz had shared them to me.*

	Dependent variable: Real House Price Index Annual Growth				
	(1)	(2)	(3)	(4)	(5)
$\beta_{\text{Dot-Com Bubble}}$	-0.0011 (0.0008)	-0.0012 (0.0008)	-0.0004 (0.0008)	-0.0012 (0.0008)	-0.0004 (0.0008)
$\beta_{\text{Housing Bubble}}$	-0.0050*** (0.0007)	-0.0052*** (0.0007)	-0.0048*** (0.0006)	-0.0051*** (0.0007)	-0.0047*** (0.0006)
$\beta_{\text{COVID-19 Episode}}$	0.0004 (0.0006)	0.0003 (0.0006)	-0.0002 (0.0008)	-0.0006 (0.0007)	-0.0011 (0.0007)
$\beta_{\text{Rest of the Sample}}$	0.0025*** (0.0007)	0.0021*** (0.0006)	0.0024*** (0.0006)	0.0018** (0.0006)	0.0021*** (0.0006)
Population growth	0.0174*** (0.0050)	0.0151** (0.0047)	0.0162*** (0.0047)	0.0154** (0.0047)	0.0164*** (0.0048)
Income share		0.0139*** (0.0019)	0.0126*** (0.0018)	0.0136*** (0.0019)	0.0122*** (0.0018)
Unemployment rate			-0.0087*** (0.0014)		-0.0086*** (0.0014)
Real interest rate × elasticity				-0.0024*** (0.0005)	-0.0021*** (0.0005)
Constant term	-0.0057 (0.0048)	-0.0159*** (0.0043)	-0.0127** (0.0042)	-0.0156*** (0.0043)	-0.0124** (0.0042)
Observations	5580	5580	5580	5580	5580
R^2	0.515	0.533	0.551	0.535	0.552
adj. R^2	0.496	0.514	0.533	0.516	0.534
$F - test$	17.209***	22.462***	23.822***	19.410***	21.691***

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 15: Two-way fixed effect OLS regressions with robust standard errors clustered by metropolitan statistical area in parenthesis. *Note: The sample consists of 180 US metropolitan statistical areas (MSAs) analysed from 1990 to 2021. Those selected MSAs have an average population from 1990 to 2021 larger than 100.000 inhabitants.*

	Dependent variable: Real House Price Index Annual Growth				
	(1)	(2)	(3)	(4)	(5)
$\beta_{\text{Dot-Com Bubble}}$	-0.0018	-0.0018	-0.0008	-0.0018	-0.0008
	(0.0011)	(0.0010)	(0.0010)	(0.0010)	(0.0010)
$\beta_{\text{Housing Bubble}}$	-0.0065***	-0.0067***	-0.0061***	-0.0066***	-0.0061***
	(0.0009)	(0.0009)	(0.0008)	(0.0009)	(0.0008)
$\beta_{\text{COVID-19 Episode}}$	0.0006	0.0006	0.0005	-0.0005	-0.0005
	(0.0008)	(0.0008)	(0.0009)	(0.0008)	(0.0009)
$\beta_{\text{Rest of the Sample}}$	0.0030***	0.0026***	0.0030***	0.0023***	0.0027***
	(0.0007)	(0.0007)	(0.0007)	(0.0007)	(0.0007)
Population growth	0.0171**	0.0143**	0.0153**	0.0146**	0.0155**
	(0.0057)	(0.0053)	(0.0053)	(0.0053)	(0.0053)
Income share		0.0162***	0.0147***	0.0158***	0.0144***
		(0.0023)	(0.0022)	(0.0023)	(0.0022)
Unemployment rate			-0.0085***		-0.0084***
			(0.0011)		(0.0011)
Real interest rate × elasticity				-0.0027***	-0.0025***
				(0.0007)	(0.0006)
Constant term	-0.0044	-0.0162**	-0.0124*	-0.0158**	-0.0121*
	(0.0057)	(0.0050)	(0.0048)	(0.0050)	(0.0048)
Observations	4402	4402	4402	4402	4402
R^2	0.560	0.583	0.598	0.585	0.599
adj. R^2	0.542	0.565	0.581	0.567	0.582
$F-test$	22.484***	25.045***	29.066***	21.906***	26.099***

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 16: Two-way fixed effect OLS regressions with robust standard errors clustered by metropolitan statistical area in parenthesis. *Note: The sample consists of 142 US metropolitan statistical areas (MSAs) analysed from 1990 to 2021. Those selected MSAs have an average population from 1990 to 2021 larger than 200.000 inhabitants.*

	Dependent variable: Real House Price Index Annual Growth				
	(1)	(2)	(3)	(4)	(5)
$\beta_{\text{Dot-Com Bubble}}$	-0.0020 (0.0012)	-0.0019 (0.0010)	-0.0008 (0.0011)	-0.0018 (0.0010)	-0.0008 (0.0011)
$\beta_{\text{Housing Bubble}}$	-0.0067*** (0.0009)	-0.0068*** (0.0009)	-0.0063*** (0.0009)	-0.0067*** (0.0009)	-0.0062*** (0.0009)
$\beta_{\text{COVID-19 Episode}}$	0.0008 (0.0008)	0.0009 (0.0008)	0.0010 (0.0009)	-0.0002 (0.0009)	-0.0000 (0.0009)
$\beta_{\text{Rest of the Sample}}$	0.0028*** (0.0008)	0.0026*** (0.0007)	0.0029*** (0.0008)	0.0022** (0.0007)	0.0026*** (0.0007)
Population growth	0.0158** (0.0058)	0.0132* (0.0054)	0.0142** (0.0054)	0.0135* (0.0054)	0.0144** (0.0054)
Income share		0.0154*** (0.0024)	0.0140*** (0.0023)	0.0150*** (0.0024)	0.0136*** (0.0023)
Unemployment rate			-0.0080*** (0.0011)		-0.0079*** (0.0011)
Real interest rate × elasticity				-0.0027*** (0.0007)	-0.0025*** (0.0007)
Constant term	-0.0023 (0.0060)	-0.0143** (0.0053)	-0.0099 (0.0051)	-0.0139** (0.0053)	-0.0096 (0.0051)
Observations	3596	3596	3596	3596	3596
R^2	0.580	0.600	0.614	0.602	0.615
adj. R^2	0.562	0.583	0.597	0.584	0.598
$F - test$	18.492***	20.890***	24.922***	18.141***	22.224***

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 17: Two-way fixed effect OLS regressions with robust standard errors clustered by metropolitan statistical area in parenthesis. *Note: The sample consists of 116 US metropolitan statistical areas (MSAs) analysed from 1990 to 2021. Those selected MSAs have an average population from 1990 to 2021 larger than 300.000 inhabitants.*

	Dependent variable: Real House Price Index Annual Growth				
	(1)	(2)	(3)	(4)	(5)
$\beta_{\text{Dot-Com Bubble}}$	-0.0029*	-0.0027*	-0.0017	-0.0027*	-0.0017
	(0.0014)	(0.0013)	(0.0013)	(0.0013)	(0.0013)
$\beta_{\text{Housing Bubble}}$	-0.0074***	-0.0075***	-0.0070***	-0.0075***	-0.0069***
	(0.0012)	(0.0012)	(0.0011)	(0.0012)	(0.0011)
$\beta_{\text{COVID-19 Episode}}$	0.0006	0.0007	0.0007	-0.0003	-0.0002
	(0.0009)	(0.0009)	(0.0010)	(0.0010)	(0.0011)
$\beta_{\text{Rest of the Sample}}$	0.0029***	0.0025**	0.0028**	0.0022**	0.0026**
	(0.0008)	(0.0008)	(0.0009)	(0.0008)	(0.0008)
Population growth	0.0156*	0.0130*	0.0139*	0.0132*	0.0141*
	(0.0063)	(0.0058)	(0.0058)	(0.0058)	(0.0059)
Income share		0.0156***	0.0143***	0.0152***	0.0139***
		(0.0027)	(0.0026)	(0.0027)	(0.0026)
Unemployment rate			-0.0079***		-0.0078***
			(0.0011)		(0.0011)
Real interest rate × elasticity				-0.0026**	-0.0024**
				(0.0008)	(0.0008)
Constant term	-0.0006	-0.0126*	-0.0071	-0.0122*	-0.0068
	(0.0066)	(0.0057)	(0.0055)	(0.0057)	(0.0055)
Observations	3069	3069	3069	3069	3069
R^2	0.586	0.606	0.619	0.607	0.620
adj. R^2	0.567	0.588	0.601	0.589	0.602
$F - test$	14.842***	17.186***	22.167***	14.663***	19.383***

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 18: Two-way fixed effect OLS regressions with robust standard errors clustered by metropolitan statistical area in parenthesis. *Note: The sample consists of 99 US metropolitan statistical areas (MSAs) analysed from 1990 to 2021. Those selected MSAs have an average population from 1990 to 2021 larger than 400.000 inhabitants.*

	Dependent variable: Real House Price Index Annual Growth				
	(1)	(2)	(3)	(4)	(5)
$\beta_{\text{Dot-Com Bubble}}$	-0.0010	-0.0011	-0.0004	-0.0011	-0.0004
	(0.0008)	(0.0008)	(0.0008)	(0.0008)	(0.0008)
$\beta_{\text{Housing Bubble}}$	-0.0049***	-0.0051***	-0.0048***	-0.0050***	-0.0047***
	(0.0007)	(0.0007)	(0.0006)	(0.0007)	(0.0006)
$\beta_{\text{COVI-19 Episode}}$	0.0005	0.0004	-0.0001	-0.0005	-0.0010
	(0.0007)	(0.0006)	(0.0007)	(0.0007)	(0.0007)
$\beta_{\text{Placebo (2009-2013)}}$	0.0043***	0.0040***	0.0035***	0.0036***	0.0031***
	(0.0009)	(0.0009)	(0.0009)	(0.0009)	(0.0008)
$\beta_{\text{Rest of the Sample}}$	0.0020**	0.0016**	0.0020***	0.0014*	0.0018**
	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)
Population growth	0.0173***	0.0150***	0.0160***	0.0153***	0.0163***
	(0.0048)	(0.0045)	(0.0045)	(0.0045)	(0.0046)
Income share		0.0132***	0.0118***	0.0129***	0.0115***
		(0.0019)	(0.0018)	(0.0019)	(0.0018)
Unemployment rate			-0.0083***		-0.0083***
			(0.0014)		(0.0014)
Real interest rate × elasticity				-0.0023***	-0.0021***
				(0.0005)	(0.0005)
Constant term	-0.0059	-0.0154***	-0.0120**	-0.0150***	-0.0117**
	(0.0045)	(0.0042)	(0.0040)	(0.0042)	(0.0040)
Observations	5797	5797	5797	5797	5797
R^2	0.504	0.521	0.536	0.522	0.538
adj. R^2	0.484	0.501	0.518	0.503	0.519

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 19: Two-way fixed effect OLS regressions with robust standard errors clustered by metropolitan statistical area in parenthesis. *Note: The placebo episode period is defined from 2009 to 2013. The sample consists of 187 US metropolitan statistical areas (MSAs) analysed from 1990 to 2021.*

	Dependent variable: Real HPI Annual Growth	
	(1)	(2)
$\beta_{\text{Dot-Com Bubble}}$	0.0017	0.0003
	(0.0018)	(0.0019)
$\beta_{\text{Housing Bubble}}$	-0.0028*	-0.0032**
	(0.0011)	(0.0010)
$\beta_{\text{COVID-19 Episode}}$	0.0037	0.0005
	(0.0024)	(0.0021)
$\beta_{\text{Rest of the Sample}}$	0.0056*	0.0043*
	(0.0022)	(0.0020)
Population growth	0.0091	0.0101
	(0.0069)	(0.0064)
Income share	0.0105**	0.0090**
	(0.0034)	(0.0030)
Real interest rate	-0.0048**	-0.0047**
× elasticity	(0.0016)	(0.0015)
Construction wages	0.0000***	0.0000**
(in real terms)	(0.0000)	(0.0000)
Unemployment rate		-0.0153***
		(0.0035)
Constant term	0.1617**	0.1379*
	(0.0558)	(0.0570)
Observations	1430	1430
R^2	0.600	0.623
Adjusted R^2	0.572	0.596
$F-test$	6.3791***	9.1298***

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 20: Two-way fixed effect OLS regressions with robust standard errors clustered by metropolitan statistical area in parenthesis. *Note: The sample consists of 65 US metropolitan statistical areas (MSAs) analysed from 1996 to 2021.*

	Dependent variable: Real House Price Index Annual Growth				
	(1)	(2)	(3)	(4)	(5)
$\beta_{\text{Dot-Com Bubble}}$	-0.0012 (0.0009)	-0.0013 (0.0008)	-0.0005 (0.0008)	-0.0013 (0.0008)	-0.0005 (0.0008)
$\beta_{\text{Housing Bubble}}$	-0.0050*** (0.0007)	-0.0052*** (0.0007)	-0.0048*** (0.0006)	-0.0051*** (0.0007)	-0.0048*** (0.0006)
$\beta_{\text{COVID-19 Episode}}$	0.0003 (0.0007)	0.0002 (0.0006)	-0.0003 (0.0008)	-0.0007 (0.0007)	-0.0011 (0.0008)
$\beta_{\text{Rest of the Sample}}$	0.0024*** (0.0006)	0.0021*** (0.0006)	0.0023*** (0.0006)	0.0018** (0.0006)	0.0020*** (0.0006)
Population growth	0.0175*** (0.0046)	0.0151*** (0.0044)	0.0161*** (0.0044)	0.0154*** (0.0044)	0.0164*** (0.0044)
Income share		0.0131*** (0.0019)	0.0118*** (0.0017)	0.0128*** (0.0018)	0.0115*** (0.0017)
Unemployment rate			-0.0085*** (0.0013)		-0.0084*** (0.0014)
Real interest rate × elasticity				-0.0024*** (0.0005)	-0.0022*** (0.0005)
Constant term	-0.0591*** (0.0092)	-0.0680*** (0.0086)	-0.0618*** (0.0084)	-0.0707*** (0.0089)	-0.0643*** (0.0086)
Observations	5797	5797	5797	5797	5797
R^2	0.504	0.521	0.506	0.523	0.486
Adjusted R^2	0.501	0.518	0.502	0.519	0.483
Wald test (*bootstrapping*)	9542.16***	10950.92***	7675.05***	11410.19***	7740.88***

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 21: Two-way fixed effect OLS regressions with robust standard errors clustered by metropolitan statistical area in parenthesis. *Note: The last four rows include bootstrapping with 2.000 replications. It has been decided to apply 2.000 replications consistently with the recommendations of Davison and Hinkley (1997). That is, for 95% confidence intervals the selected number of bootstrapping simulations should be between 1.000 and 2.000. The studied sample consists of 187 US metropolitan statistical areas (MSAs) analysed from 1990 to 2021.*

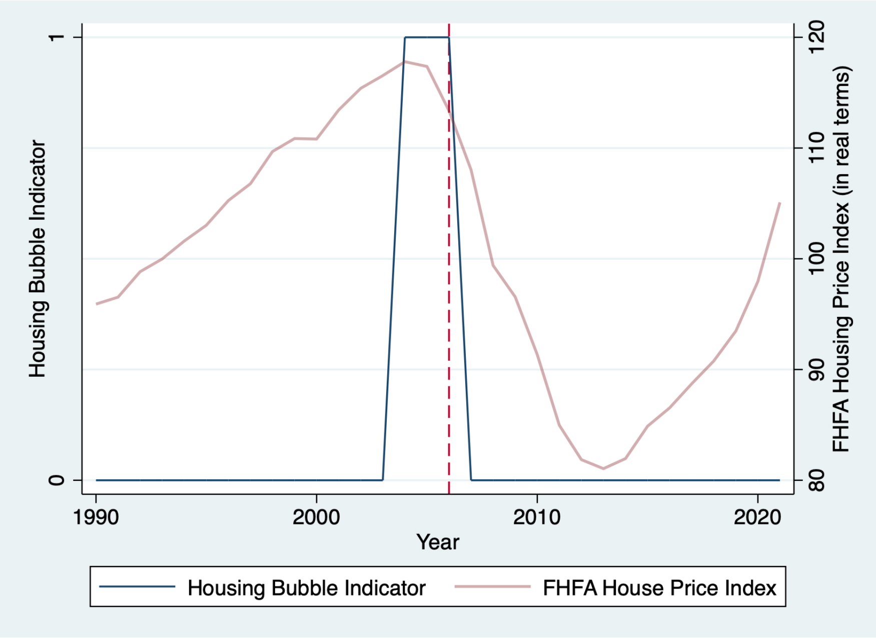

Figure 11: Metropolitan housing bubble indicator results and real home price evolution for Cleveland-Elyria, OH. *Note: When the indicator equals one, it indicates a potential housing bubble episode at year* t*. In contrast, when it equals zero, it detects the non-existence of a bubble attached to houses. The computed average population of this MSA from 1990 to 2021 is 2.102.029,30 inhabitants. Finally, with the red dotted line, the burst of the Housing Bubble (i.e. 2006) is remarked*

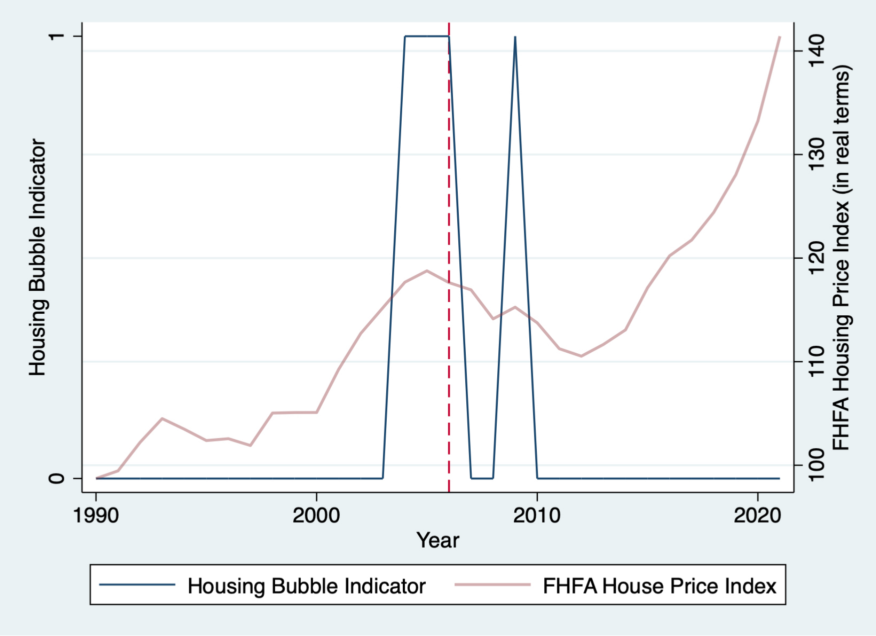

Figure 12: Metropolitan housing bubble indicator results and real home price evolution for Pittsburgh, PA. *Note: When the indicator equals one, it indicates a potential housing bubble episode at year* t*. In contrast, when it equals zero, it detects the non-existence of a bubble attached to houses. The computed average population of this MSA from 1990 to 2021 is 2.395.025,50 inhabitants. Finally, with the red dotted line, the burst of the Housing Bubble (i.e. 2006) is remarked*

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