



# DENMARK

## SELECTED ISSUES

June 2016

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# DENMARK

## SELECTED ISSUES

May 31, 2016

Approved By  
**The European  
Department**

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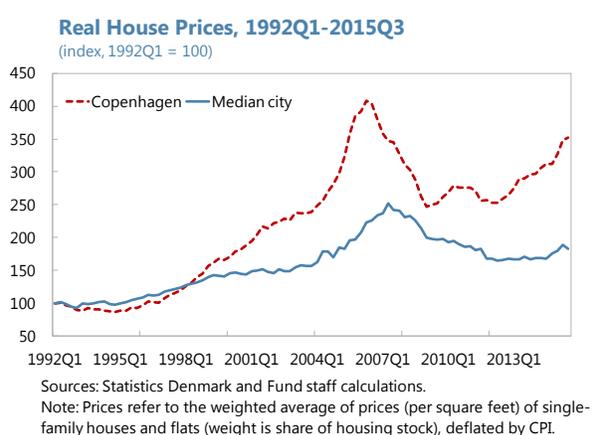
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# THE GREAT DIVERGENCE: REGIONAL HOUSE PRICES IN DENMARK<sup>1</sup>

Recent house price developments in Denmark have been characterized by a growing divergence between different parts of the country, with big cities such as Copenhagen and environs experiencing much more rapid price increases than other parts. This paper examines the factors contributing to this price divergence. In an empirical analysis, municipal-level data are used to estimate the equilibrium house price level for each Danish city—the level explained by economic fundamentals—and to infer the extent to which municipal house prices may be overvalued or undervalued. The analysis points to emerging overvaluation in Copenhagen and Frederiksberg's housing markets—particularly in the market for owner-occupied flats. The large difference in regional price trends may call for regional differentiation in macro-prudential and other housing policies to address housing market risks.

## A. Introduction

**1. There is a large divergence in house price patterns across Denmark.** Following a large price correction after the 2006–07 housing boom, house prices started to recover in the Copenhagen region in early 2012, whereas in other regions (e.g., North and East Zealand) prices have started rising only recently. The average real price per square feet of housing<sup>2</sup> in Copenhagen municipality increased by about 43 percent between 2012Q1 and 2015Q3—approaching its pre-crisis peak—compared to just over 11 percent in the median city. Over the first three quarters of 2015, prices also increased robustly in other major municipalities (e.g., Frederiksberg and Aalborg). The market for owner-occupied flats is generally seeing larger price increases compared to that for single-family homes—partly as flats are relatively concentrated in big cities. However, there is a wide distribution of price growth across the country, with some municipalities experiencing price



### Growth of Real House Prices, 2015 (y/y percent)

	Houses 1/	Flats 2/
Copenhagen	8.3	10.2
Aarhus	6.4	9.8
Odense	4.2	7.6
Aalborg	7.1	9.7
Frederiksberg	8.6	9.5
Esbjerg	-1.1	0.5
Median	6.3	8.2
10th percentile	-0.5	-2.9
90th percentile	11.7	15.9

Sources: Statistics Denmark and Fund staff calculations.

Note: 2015 figures cover the first three quarters.

1/ Refers to detached/terraced houses

2/ Refers to owner-occupied flats

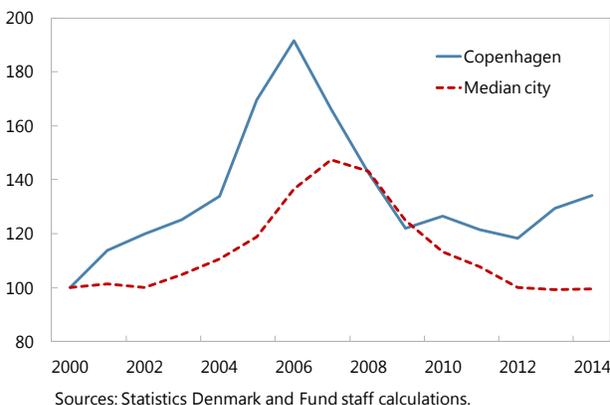
<sup>1</sup> Prepared by Giang Ho.

<sup>2</sup> Weighted average of prices for single-family homes and owner-occupied flats.

declines and sluggish turnover, creating a ‘multi-speed’ housing market (Dam, Hvolbol, and Rasmussen, 2014; Pedersen and Isaksen, 2015).

**2. For policymakers, it is important to monitor the extent to which house prices deviate from economic fundamentals.** The housing market is of great importance to both financial and macroeconomic stability and a more stable housing market (without pronounced boom-bust cycles) would contribute to smoother economic development. While it is difficult to detect housing ‘bubbles’ in real time, it is helpful to gauge the degree of overvaluation or undervaluation in the housing market by comparing actual price levels to those that would be justified by demand and supply factors. One simple valuation measure—the price-to-income (PTI) ratio<sup>3</sup>—indicates that valuations in Copenhagen in 2014 were at a level comparable to that in 2004, right before the last price run-up. Meanwhile, median valuations have been much more subdued. The large regional differences in Denmark’s housing market may warrant a regional approach, both in terms of empirical analysis and policy implications.

**Price-to-Income Ratio in Copenhagen and Median City**  
(Index, 2000=100)



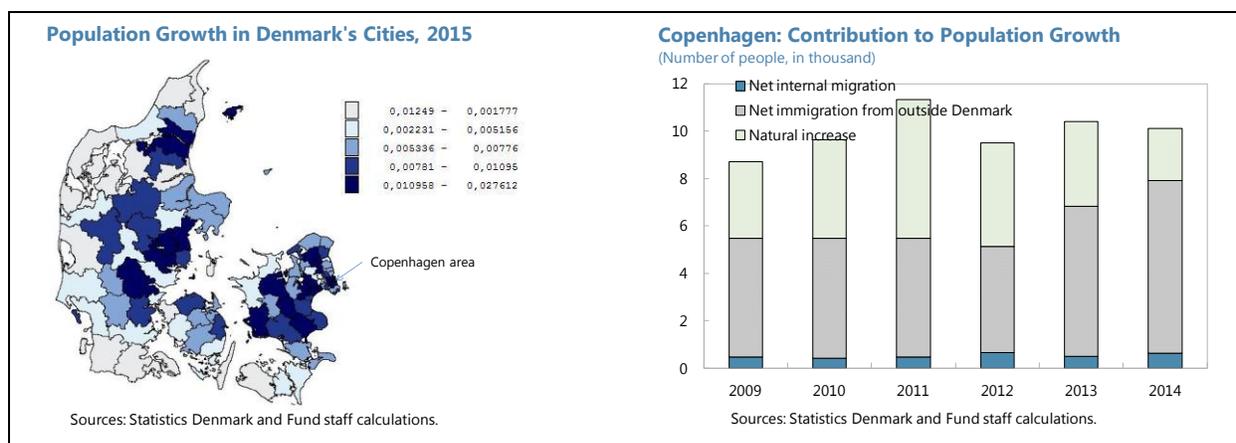
**3. The paper is organized as follows:** Section B documents the factors contributing to the regional differences in house prices across Denmark. Section C presents the analysis of equilibrium house prices using data from 96 Danish municipalities. Section D discusses the policy implications and concludes.

## B. Factors Contributing to Regional Price Differences

**4. The high demand for owner-occupied housing in Denmark’s large cities is underpinned by demographic trends.** Population growth varies widely across the country; urban centers are becoming larger while some rural areas are losing population. For example, between 2012 and end-2015, the population of Copenhagen municipality increased by 42,500 inhabitants—equivalent to 7.7 percent growth—while the number of inhabitants in the municipality of Lolland was reduced by 2,600—or a decline of 6 percent. Much of the large influx of population into the capital is explained by immigration from outside Denmark, with internal migration playing a contributing but secondary role. According to Statistics Denmark’s projections, cities will continue to grow in size over the next few decades at the expense of rural areas. The age composition of large

<sup>3</sup> The PTI at municipal level is calculated by dividing nominal property prices (weighted average of single-family houses and flats) by nominal average family incomes. The latter series is only available from 2000 onwards, and 2015 figure is not yet available.

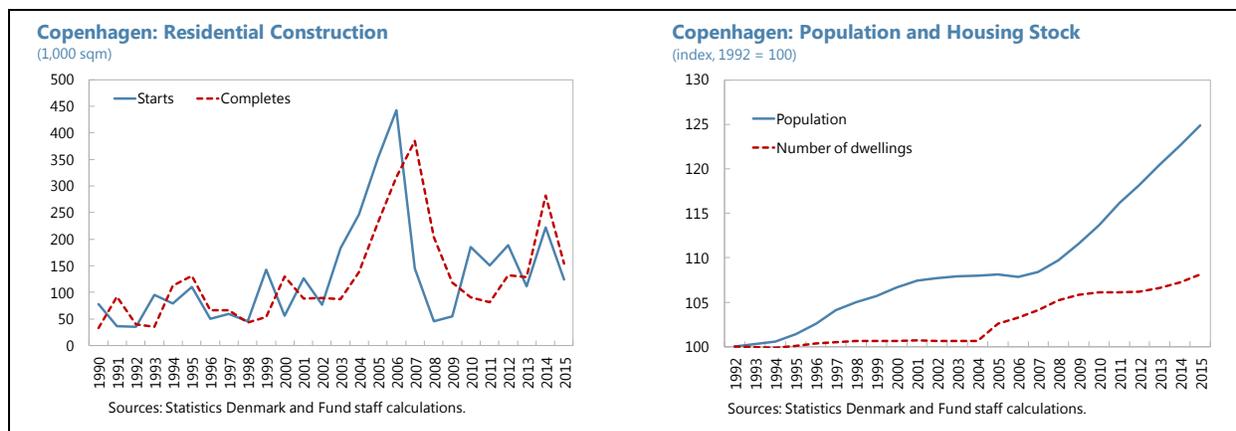
cities' populations is also more conducive to home ownership. Currently, about 40 percent of Copenhagen's residents belong to the 25–44 age group—those who are more likely to demand owner-occupied housing—compared to 25 percent for Denmark as a whole.



**5. Faster rising income and employment in big cities also exerts upward pressure on housing demand.** Denmark's labor market as a whole has been on a modest recovery track since 2012, but performance is uneven across regions, partly reflecting differences in the education and age composition as well as the types of jobs prevalent in each region. Over the period 2012–14 (2015 figure not yet available), real personal disposable income grew by 4.3 percent in the municipality of Copenhagen and 5 percent in Frederiksberg, compared to 3.5 percent for Denmark as a whole. Employment is also expanding more rapidly in the capital region than in other regions. Favorable economic and labor market trends reinforce the population trends by attracting more rural-urban migration as well as labor migrants from other parts of Europe.

**6. Demand is also fueled by the favorable trends in the user cost of housing.** The user cost depends on, among other factors, mortgage interest rates and housing taxes. Interest rates—both short and long term—have declined to very low levels in Denmark in recent years. The nominal freeze on valuations for the purpose of property value taxes introduced in 2002 implies that the effective tax rate has fallen relatively sharply in areas of rising house prices such as Copenhagen, since property taxes cannot increase with the rising market value of the property. Moreover, in 2016 the government has introduced a similar nominal freeze for land taxes, which will lower also the effective land tax rate in high price growth areas (Danmarks Nationalbank's Monetary Review, 2015Q4).

**7. Meanwhile, housing supply in big cities hardly keeps up with housing demand.** Residential construction in Copenhagen—measured by either housing starts or completes—has picked up after the crisis and is now at a higher level than during the pre-boom years, but remains much lower than during the 2006–07 peak. Stricter zoning codes and land use regulations in Copenhagen combined with rapidly rising land prices are restricting new residential construction. As a consequence, demand for housing has outpaced supply in Copenhagen, with the housing stock expanding much slower than population (see also Chapter II which discusses housing supply issues).



### C. A Quantitative Perspective

**8. This section presents a simple model relating municipal house prices to the demand and supply fundamentals discussed above.** As in Meen (2002), house prices are often modeled using an inverted demand curve.<sup>4</sup> The observed real price level in municipality  $i$ ,  $P_{it}$ , is modeled as a function of the long-run equilibrium real house price,  $P_{it}^*$ , which is determined by the housing stock  $S_{it}$ , demand shifters  $X_{it}$ , time-invariant unobserved municipal characteristics (e.g., amenities and locations—captured by the fixed effects  $\alpha_i$ ), as well as common shocks (captured by time fixed effects  $\mu_t$ ):

$$P_{it} = \beta_1 S_{it} + \beta_2 X_{it} + \alpha_i + \mu_t + \varepsilon_{it} = P_{it}^* + \varepsilon_{it} \quad (1)$$

The demand shifters include municipal population in the 25-44 age group, municipal unemployment rate<sup>5</sup>, the real lending rate<sup>6</sup>, and the effective property tax rate<sup>7</sup>. An index of real construction costs is also included. All variables except for the lending rate and construction costs are available at the municipal level. Following Hort (1998), for robustness check, the baseline specification is augmented with the lags of the growth rates of all level variables to mitigate finite-sample bias.<sup>8</sup> We estimate

<sup>4</sup> Recent studies for Nordic countries using the same approach include Turk (2015), Claussen (2013) for Sweden, and Anundsen and Jansen (2013) for Norway. As we are most interested in the determinants of long-run equilibrium house prices in this study, a full-fledged error correction model with both long-run and short-run dynamics is not necessary.

<sup>5</sup> The series for average personal disposable income at the municipal level is only available from 2002, so we use the unemployment rate series instead.

<sup>6</sup> As mortgage interest rate is not available far back in time, we use instead an aggregate lending rate.

<sup>7</sup> Calculated by dividing property tax payments by property value.

<sup>8</sup> Asymptotically, the long-run equation may be consistently estimated by OLS even though the dynamics and endogeneity of some variables are ignored. In finite samples, however, ignoring the short-term dynamics may lead to substantial bias.

equation (1) separately for each market segment (single family houses or owner-occupied flats). The estimation sample covers 96 municipalities over the period 1996–2015.

**9. Results indicate that these factors play significant roles in driving municipal house prices** (Table 1). On the demand side, for example, a 10 percent increase in a municipal’s 25–44 aged population is associated with prices being 6.1 percent higher for single-family homes and 2.3 percent for flats. Prices are also higher in municipalities where the unemployment rate or the real user cost of housing (as captured by the lending rate and property tax rate) is lower. Lower property taxes also contribute to spurring housing demand and increasing prices of single-family homes; however, in our estimation property taxes do not have a statistically significant effect on the long-run prices of owner-occupied flats. On the supply side, a more limited housing stock or a rise in construction cost is associated with higher prices. Together, these factors explain about 80 percent of the variation in municipal house prices.

**Table 1. Denmark: Long-Run Determinants of Real House Prices**

VARIABLES	Houses		Flats	
	(1)	(2)	(3)	(4)
25–44 aged population, log	0.611 [0.110]***	0.585 [0.100]***	0.230 [0.137]*	0.236 [0.144]
Unemployment rate, percent	-0.029 [0.006]***	-0.030 [0.006]***	-0.032 [0.009]***	-0.045 [0.011]***
Real lending rate, percent	-0.124 [0.021]***	-0.205 [0.034]***	-0.197 [0.069]***	-0.198 [0.067]***
Effective property tax rate, per thous	-0.014 [0.007]*	-0.016 [0.006]**	-0.007 [0.010]	-0.005 [0.012]
Housing stock, log	-0.540 [0.085]***	-0.525 [0.089]***	-0.206 [0.049]***	-0.188 [0.050]***
Real construction cost, log	2.913 [0.506]***	2.796 [0.503]***	3.971 [0.967]***	3.837 [0.999]***
Observations	1,894	1,698	1,516	1,293
R-squared	0.847	0.840	0.802	0.767
Number of municipalities	96	96	89	85
Controlling for dynamics	N	Y	N	Y

Sources: Fund staff estimates.

Note: Dependent variable is the logarithm of real house prices. Panel consists of about 96 municipalities over 1996–2015. A full set of year and municipality fixed effects are included. Specifications (2) and (4) control for the lags of the growth rates of all level variables. Statistical significance \*\*\* 1%, \*\* 5%, \* 10%.

**10. The model can be used to gauge the extent to which house prices deviate from long-run equilibrium levels.** While indicators such as the price-to-income ratio are indicative, they are limited in the sense that they only consider one ‘fundamental’ variable, e.g., income, in assessing the degree of over- or undervaluation. Using our estimated model, we consider house prices in a particular municipality overvalued if the observed prices are higher than the estimated long-run level based on multiple determinants. In other words, using notations from equation (1), the degree of price deviation from long-run values is measured by:

$$\varepsilon_{it} = P_{it} - P_{it}^*$$

The implied valuations from this exercise should be interpreted with caution, in the sense that the estimated equilibrium price levels are model-dependent, and can change considerably depending on the underlying fundamentals included in the model.

**11. By our metric, current house prices in some large Danish municipalities are found to be moderately overvalued.** The average prices of single-family homes in Copenhagen in 2015 are found to be about 9 percent higher than the estimated equilibrium value (Figure 1). While this is only about half of the estimated deviation during the 2006–07 peak, it suggests the beginnings of overvaluation and prices thus far continue to rise. Meanwhile, the average prices of owner-occupied flats are about 19 percent above the estimate value—which is comparable to the level during the 2006–07 peak (Figure 2). Results are mixed for other major municipalities, with little overvaluation in Odense and Esbjerg whereas Frederiksberg’s housing market is exhibiting even larger price overvaluation than Copenhagen’s.

## D. Conclusion

**12. Regional price divergence in Denmark’s housing market reflects a number of demand and supply factors.** Rapid population and income growth in big cities pushes up demand for housing, especially as the housing stock does not expand at a commensurate pace due to land use regulations and zoning codes, which tend to be tighter in the already densely populated metropolitan areas. On top of this, historically low interest rates and tax incentives for home-ownership affect house prices in big cities disproportionately since the urban demographic structure tends to be skewed towards population of home-buying age (e.g., 25–44 age group).

**13. The regional divergence in Denmark’s housing market may call for regionally-differentiated housing policy.** Debt-to-income (DTI) caps, even if applied nationwide, would naturally have regionally-differentiated effects in Denmark given the high concentration of indebted households in high price growth areas. The authorities could also consider introducing other macro-prudential measures such as loan-to-value (LTV) limits with different degrees of stringency across regions to more effectively target high-risk areas such as Copenhagen without hampering the nascent recovery in other regions’ housing market (see also Chapter III). Such a strategy has recently

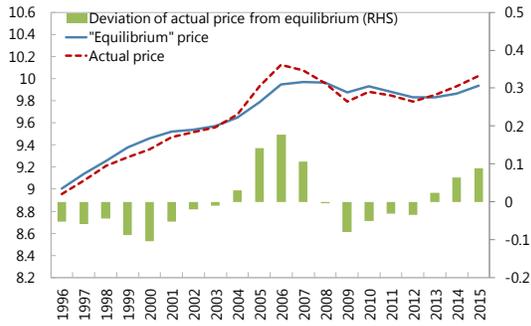
been applied in, for example, New Zealand, where restrictions on high-LTV lending were tightened specifically for the Auckland housing market (Reserve Bank of New Zealand, 2015).<sup>9</sup> In this vein, the Danish authorities have recently taken welcome targeted measures to strengthen mortgage lending standards, including issuing guidelines—“Seven Best Practices”—for banks in areas with rapid house price increases. Macroprudential measures aside, ending the freeze of property and land taxes—which contributes to property demand disproportionately in high price growth areas—would also be a key measure to address regional pressures. On the supply side, incentives for new residential construction could be improved by relaxing land use regulations and zoning codes in pressured urban centers to better align housing supply with population increase and housing demand.

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<sup>9</sup> Specifically, starting in October 2015, the Reserve Bank of New Zealand introduced a new restriction on loans to property investors in the Auckland region with an LTV higher than 70 percent (i.e., to set a speed limit on such loans at close to zero). For all residential lending outside the Auckland region, the Bank proposed to increase the existing speed limit for loans with an LTV higher than 80 percent from 10 to 15 percent, to recognize relatively subdued housing market conditions outside Auckland.

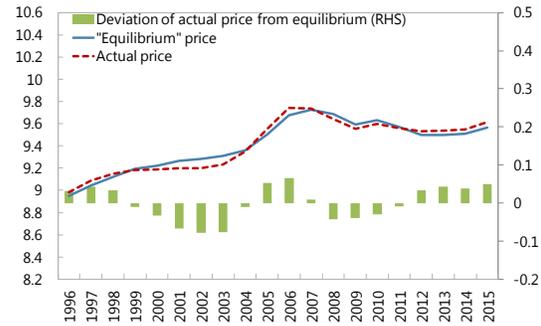
**Figure 1. Denmark: Estimated Equilibrium and Actual Prices in Selected Cities—Houses**

**Copenhagen**  
(log level)



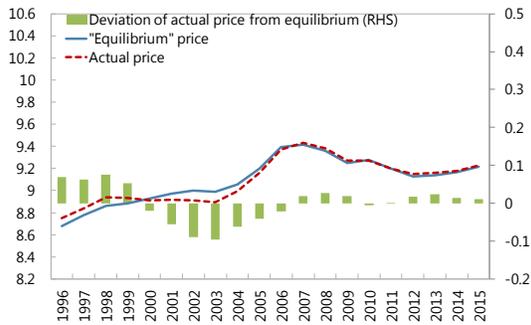
Sources: Statistics Denmark and Fund staff calculations.

**Aarhus**  
(log level)



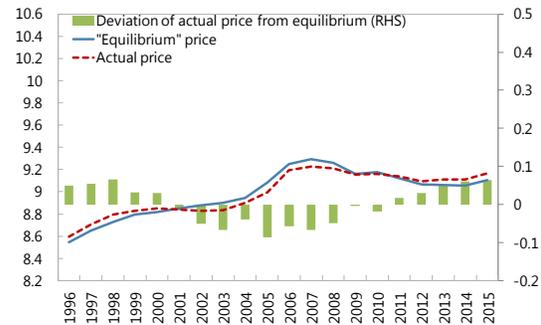
Sources: Statistics Denmark and Fund staff calculations.

**Odense**  
(log level)



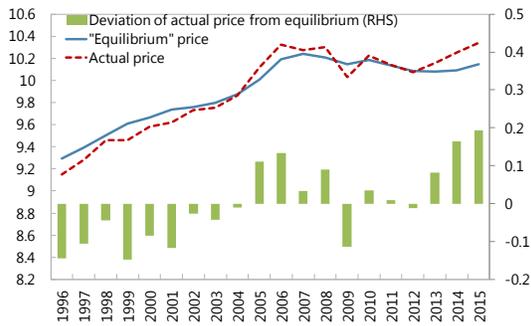
Sources: Statistics Denmark and Fund staff calculations.

**Aalborg**  
(log level)



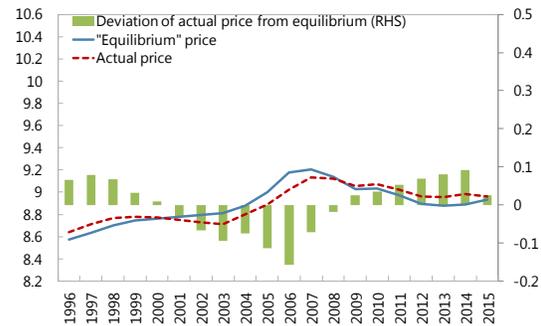
Sources: Statistics Denmark and Fund staff calculations.

**Frederiksberg**  
(log level)



Sources: Statistics Denmark and Fund staff calculations.

**Esbjerg**  
(log level)

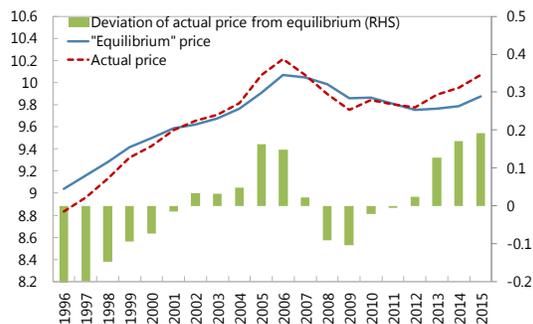


Sources: Statistics Denmark and Fund staff calculations.

**Figure 2. Denmark: Estimated Equilibrium and Actual Prices in Selected Cities—Flats**

**Copenhagen**

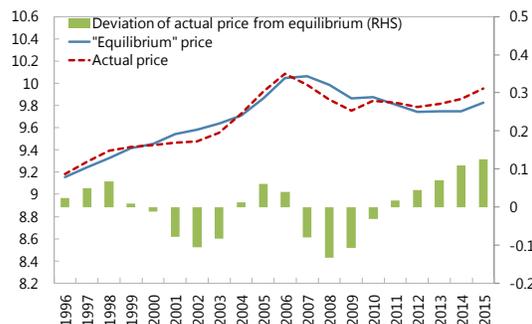
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Sources: Statistics Denmark and Fund staff calculations.

**Aarhus**

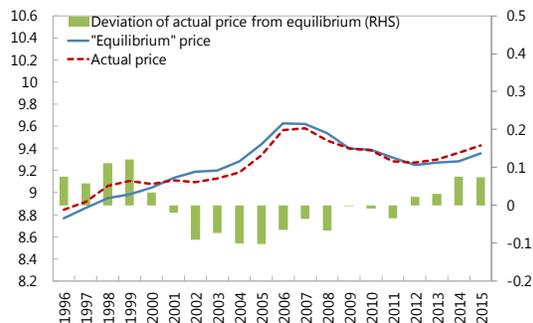
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Sources: Statistics Denmark and Fund staff calculations.

**Odense**

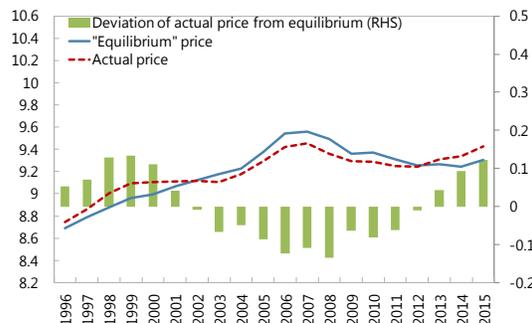
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Sources: Statistics Denmark and Fund staff calculations.

**Aalborg**

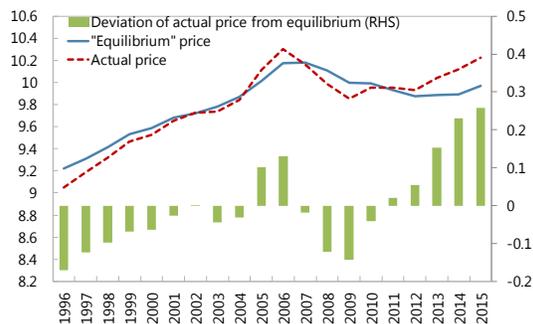
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Sources: Statistics Denmark and Fund staff calculations.

**Frederiksberg**

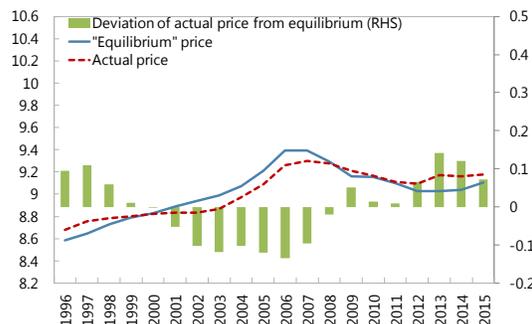
(log level)



Sources: Statistics Denmark and Fund staff calculations.

**Esbjerg**

(log level)



Sources: Statistics Denmark and Fund staff calculations.

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# HOUSE PRICES IN DENMARK'S CITIES: THE ROLE OF SUPPLY<sup>1</sup>

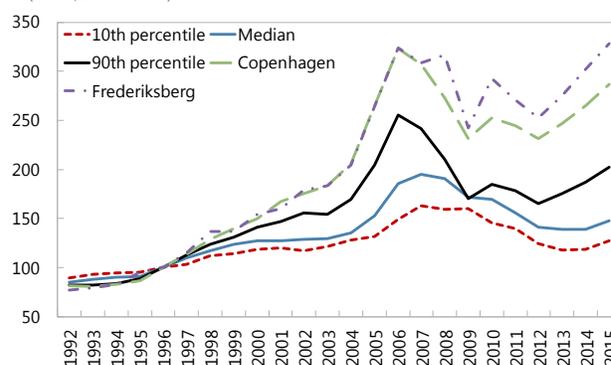
*This paper highlights the role of housing supply constraints in driving prices in Denmark's owner-occupied housing markets, especially in pressured areas such as Copenhagen. It first briefly discusses the main factors constraining housing supply in Denmark's largest cities, including a rigid planning regime and rental regulation. The paper then uses municipal-level data to estimate the elasticity of housing supply for each municipality, and show that supply constraints can significantly amplify the price response to a demand shock. Last, a policy experiment is conducted to illustrate the differentiated impact that an interest rate shock or an income shock may have on house prices in areas with different supply conditions.*

## A. Introduction

### 1. House price booms and busts in Denmark, like in many other countries, are a big-city phenomenon.

There is large divergence between house prices in major urban areas such as Copenhagen and Frederiksberg and other parts of the country, suggesting that housing markets are highly localized. This is not only a feature of the current juncture but also of the earlier house price cycle. For example, between 1996 and 2006, prices increased by a cumulative 85 percent in real terms in the median city, compared to 256 percent at the 90<sup>th</sup> percentile and over 320 percent in Copenhagen city. The post-2007 price corrections were also larger in cities with previously major price run-ups.

**Real House Prices in Danish Cities**  
(index, 1996 = 100)



Sources: Statistics Denmark and Fund staff calculations.

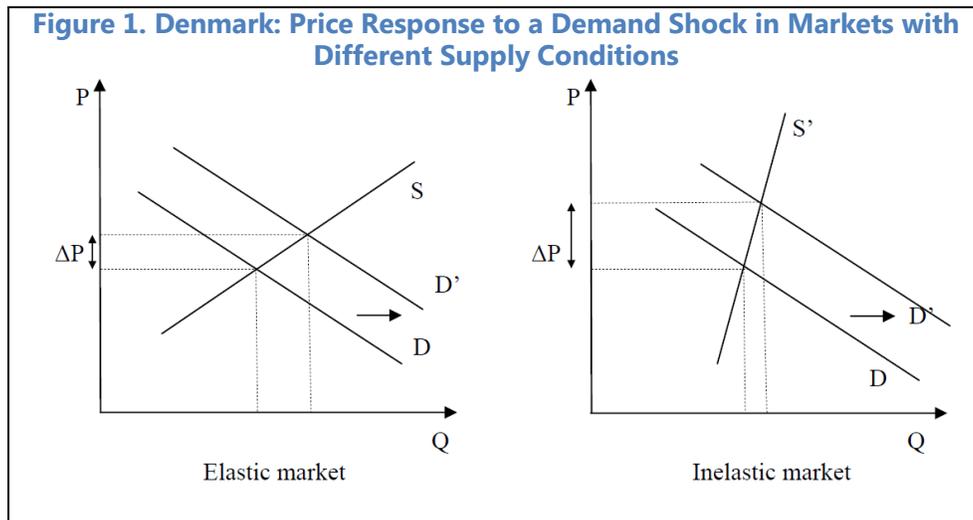
Note: Prices refer to the price (per square feet) of single family houses, deflated by CPI.

### 2. Differences in housing supply conditions across cities can contribute to the price divergence.

While the literature has traditionally focused on shocks to housing demand (e.g., income shocks and population growth) in explaining house price developments, the role of housing supply constraints—how fast the stock of housing adjusts to accommodate a demand shock—has just started to gain attention. Subject to a given increase in demand, markets with inelastic supply cannot generate new construction quickly to meet the targeted housing stock, resulting in a larger price increase relative to markets with more elastic supply (Figure 1). Thus, in theory, housing supply constraints can have an effect on short-run price changes through its interaction with demand

<sup>1</sup> Prepared by Giang Ho.

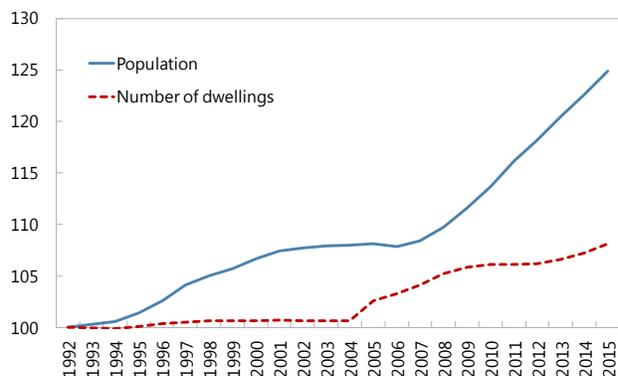
shocks. Supply conditions are determined by both natural (i.e., topographical) and man-made constraints (e.g., local land use regulations, including zoning codes and building permits).



**3. Supply conditions vary widely across Denmark’s cities, with Copenhagen and the surrounding cities exhibiting most severe constraints.** While Denmark as a whole experienced a construction boom during 2006–07—resulting in an oversupply of housing in some areas—rapid population growth as a result of rural-urban migration and immigration continues to fuel housing demand in large cities, notably Copenhagen. On the supply side, stricter zoning codes, land use regulations, and rental controls in Copenhagen relative to other parts of the country have restricted the supply of both owner-occupied and rental housing. As a result, housing demand has constantly outpaced supply in Copenhagen, causing local land prices to skyrocket (Danmarks Nationalbank’s Monetary Review, 2014Q3). Another manifestation is the wide range of vacancy rates across Denmark’s cities; while some municipalities in Denmark are currently experiencing vacancy rates as high as 30 percent, the vacancy rate remains near zero in Copenhagen area.

**Copenhagen: Population and Housing Stock**

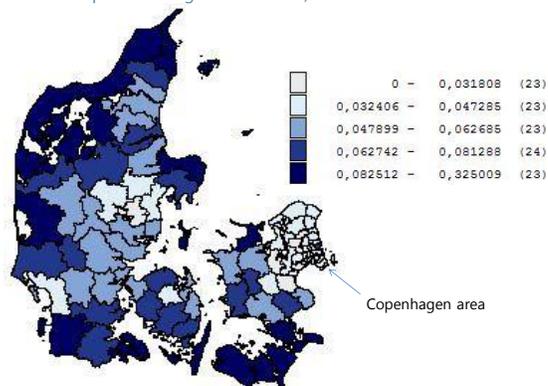
(index, 1992 = 100)



Sources: Statistics Denmark and Fund staff calculations.

**Vacancy Rate in Denmark’s Cities, 2015**

(share of unoccupied dwellings in total stock)



Sources: Statistics Denmark and Fund staff calculations.

**4. The paper is organized as follows:** Section B discusses the factors constraining housing supply in Denmark's largest cities. Section C presents the estimation of local housing supply elasticity. Section D estimates a model of municipal house price growth—with focus on the role of supply, and discusses the policy experiment. Section E concludes.

## **B. Factors Contributing to Supply Constraints in Denmark's Large Cities**

**5. Spatial planning in Denmark is characterized by a top down structure and a strictly enforced zoning system.** The zoning law stipulates that urban growth can only take place in designated urban zones. In the Greater Copenhagen Area, which encompasses the municipalities of Copenhagen and Frederiksberg, the Finger Plan ('Fingerplanen') introduced in 1947 sets forth that urban development is restricted to each of five 'fingers' served by collective rail transport ('S-tog') by preserving green areas between the fingers. Even though municipalities were given increased planning powers and responsibilities in the local government reform in 2007, this region is overseen by the Ministry of the Environment, which has the power to veto a municipal plan proposal if the proposal contradicts national interests. As a result, the municipalities in the Greater Copenhagen Area are experiencing greater state regulation of their planning decision making than elsewhere in Denmark (Monk and others, 2013).

**6. The approach to land supply in Denmark is relatively passive.** For example, Copenhagen does not own a lot of land and is very much dependent on private investors and landowners. There appear to be no specific mechanisms for bringing forward land for housing development. Land value taxation, which taxes the 'unearned increment' in land values and arguably provides an incentive to develop, has all but disappeared, and only a remnant remains in the form of a municipal real estate tax (Monk and others, 2013).

**7. Strict regulation in the private rental market creates supply-demand imbalances, putting further pressure on the owner occupied housing market.** A well-developed and efficient rental market providing a viable alternative to ownership could play a balancing role by alleviating house price pressures and smoothing housing market dynamics. Rent controls, however, impede the functioning of the private rental market by reducing the incentives to invest in rental properties and creating excess demand. While Denmark used to have very strict rental regulation through the early 1980s, subsequent deregulation has introduced a more relaxed regime (e.g., on initial rent setting). The new regime, however, only applies to dwellings built after 1991 and rent controls continue to be important with about 90 percent of private rented dwellings subject to them. Specifically, there are two main sets of rules for rent-setting; one applies a formula that relates rents to costs, and the other allows for administratively determined rents that are based on the rents of comparable dwellings. Both sets of rules produce rents that are well below market levels. Security of tenure for tenants is strong. There are significant differences in how the system is implemented between areas, with Copenhagen having some of the strongest regulation (Cambridge Centre for Housing and Planning Research, 2012).

## C. Measuring Local Housing Supply Constraints

**8. Measuring local supply constraints is challenging due to lack of data.** For the purpose of empirical analysis, one would like to ideally have an indicator of each city's available and developable land supply, as well as a measure of its regulatory restrictions related to local land use. These indicators have been developed for US metropolitan areas (e.g., Saiz, 2010 and Gyrouko and others, 2008) but are not available for Danish cities. Our empirical strategy gets around this issue in two ways. First, we directly estimate the price elasticity of housing supply using data on house prices and housing starts for Danish municipalities. Second, we use the local population density as a proxy for housing supply conditions, assuming that a more densely populated area reflects a larger degree of supply shortage. These measures are imperfect in that they cannot distinguish the effects of natural land constraints versus regulations; however, the two factors are often highly correlated (e.g., see Saiz, 2010).<sup>2</sup>

**9. We employ data on housing starts and house prices for 92 Danish municipalities to estimate the elasticity of housing supply.**<sup>3</sup> Starts refer to the number of newly-constructed houses, and prices refer to the realized transaction prices, deflated by the national consumer price index. The sample contains data for the period 1992–2014. Panel cointegration tests indicate that the two series in log levels are cointegrated in the majority of markets (with one cointegrating relationship). Thus, following Wheaton and others (2014), we use the Vector Error Correction Model (VECM) to deal with both stationarity and endogeneity issues. The model is represented by the system of equations:

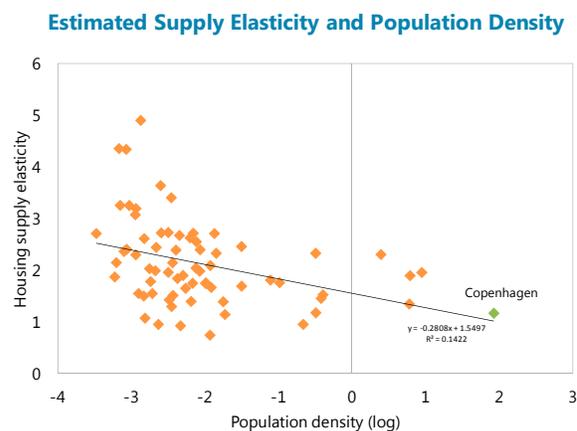
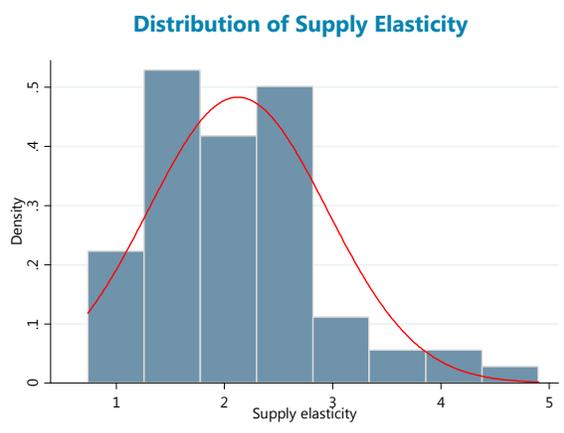
$$\begin{aligned}\Delta S_t &= \alpha_0[S_{t-1} - (\beta_1 + \beta_2 P_{t-1})] + \sum_{k=0}^n \gamma_k \Delta P_{t-k} + \sum_{k=1}^n \alpha_k \Delta S_{t-k} \\ \Delta P_t &= \alpha'_0[S_{t-1} - (\beta_1 + \beta_2 P_{t-1})] + \sum_{k=0}^n \alpha'_k \Delta S_{t-k} + \sum_{k=1}^n \gamma'_k \Delta P_{t-k}\end{aligned}$$

Here  $S_t$  refers to the logarithm of housing starts,  $P_t$  refers to the logarithm of prices, and  $\Delta$  denotes the difference operator. The parameter of primary interest—our measure of the long-run elasticity of supply—is  $\beta_2$  in the cointegrating equation, which governs the long-run relationship between housing starts and prices. The set of adjustment coefficients ( $\alpha$ ,  $\gamma$  and  $\alpha'$ ,  $\gamma'$ ) control how quickly starts and prices adjust back to the long-run relationship given a temporary deviation from the equilibrium. We use one lag for each equation, which the lag length selection procedure indicates as sufficient for most markets. The system is estimated repeatedly for each municipality using the single-step Johansen Maximum Likelihood Estimator, which makes the assumption that the errors are normally distributed.

<sup>2</sup> Saiz (2010), using data for U.S. metropolitan areas, found that geographic constraints were strongly associated with regulatory constraints. Theoretically, regulation may be endogenous as voters may explicitly restrict the supply of land to keep its value high, but only have an incentive to do so in areas where land was initially scarce.

<sup>3</sup> The administrative structure of Denmark's municipalities underwent a reform in 2007. We use the correspondence between the old structure (over 270 municipalities) and new structure (close to 100 municipalities) to splice together the pre-2007 and post-2007 series.

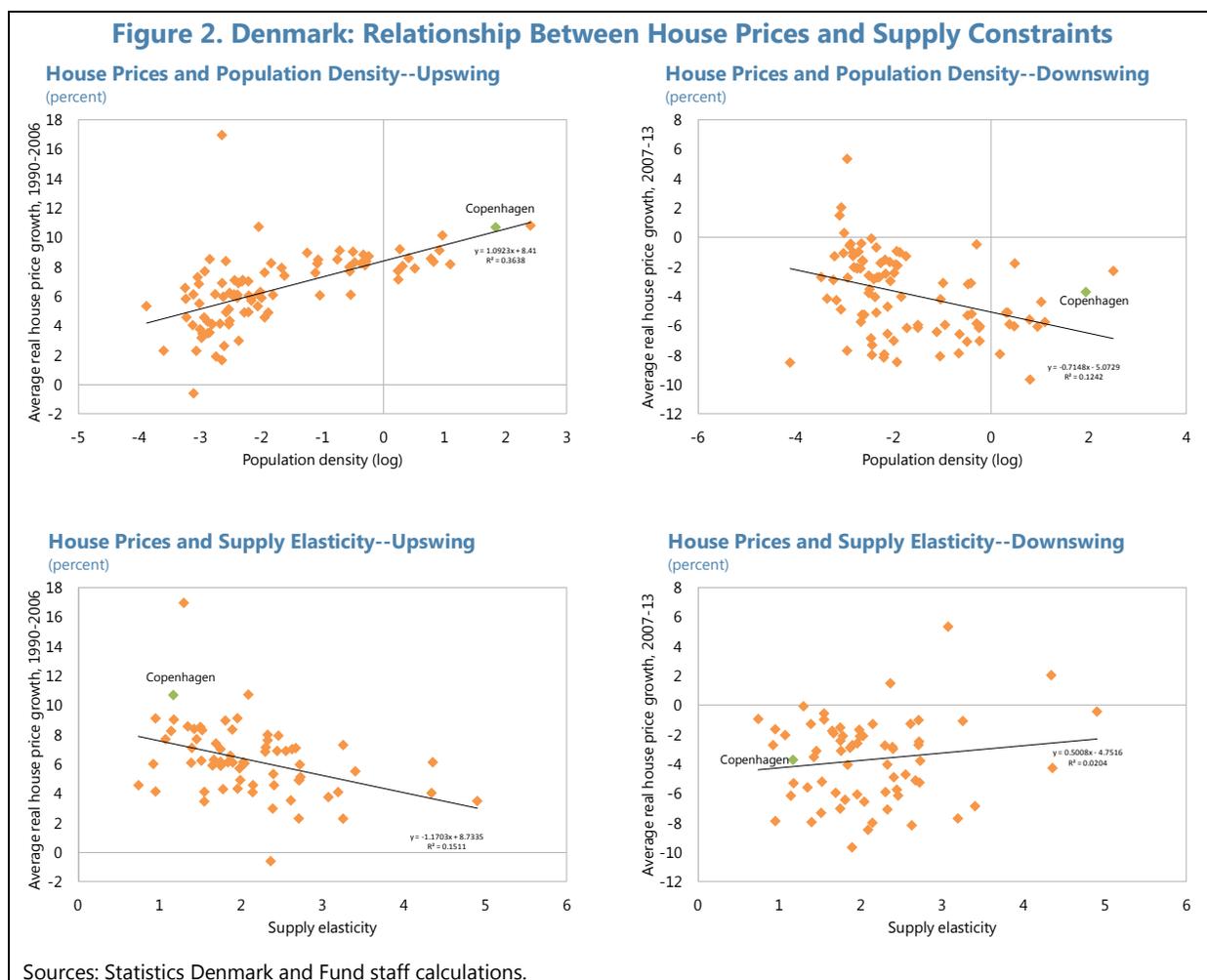
**10. The estimated elasticities show substantial regional differentiation and are negatively correlated with population density.** Out of 92 municipalities used in the estimation, 10 estimated elasticities are negative—all statistically insignificant (>10%), and another 12 elasticities are positive but insignificant. Focusing on the positive and statistically significant estimates, we have elasticity measures for 70 municipalities ranging from 0.74 to 4.9, with an average of 2.1. As expected, the estimated elasticities are negatively correlated with population density, which is our alternative measure of housing supply conditions. Copenhagen—the most densely populated urban area—also has one of the lowest housing supply elasticities in the country (1.17).



Sources: Statistics Denmark and Fund staff calculations.

## D. Impact of Housing Supply on Prices

**11. Our measures of housing supply constraints are correlated with the degree of local house price fluctuations.** In virtually all of the municipalities, the period from the early 1990s through 2006–07 exhibits an unprecedented rise in real house prices, followed by a decline of almost similar magnitude over the 2007–13 downswing. These trends resulted from shocks to the housing markets at the national (and even the regional and global) level, which propagate to all local markets to varying extents. We would expect that the degree of price responses naturally depends on how flexible supply is in each location. Indeed, cities with high population density or low estimated elasticity of housing supply recorded relatively larger price run-ups during the boom, but also more severe price declines during the bust (Figure 2). While the relationship is not perfect due to conditions that are unique to each location, it still suggests that inflexibility in the supply of housing contributes to price volatility.



**12. A dynamic panel regression approach is employed to formally estimate the impact of supply constraints on local house price growth.** We apply the methodology in Glaeser and others (2008) and Saiz (2010) while extending to a panel setting. The empirical model relates annual change in local house prices in municipality  $i$  ( $\Delta P_{i,t}$ ) to its lag, a vector of national or local demand shocks ( $\Delta X_{i,t}$ ), a measure of the time-invariant local supply constraint ( $Z_i$ ), and an interaction term between the demand shocks and the supply constraint indicator. We're most interested in the latter variable, which captures the extent to which local supply conditions magnify or mitigate the effect of a demand shock.

$$\Delta P_{i,t} = \alpha + \beta \Delta P_{i,t-1} + \gamma \Delta X_{i,t} + \delta Z_i + \theta \Delta X_{i,t} Z_i + \mu_t + \omega_i + \varepsilon_{i,t}$$

As discussed, our two alternative measures of  $Z_i$  are population density and the elasticity of housing supply estimated in the previous section. The demand factors included in the model are changes in

the national real mortgage rate<sup>4</sup> (which determines the user cost of housing), local real disposable income growth, and growth of local population in the 25–49 age group (the age cohort most likely to demand owner-occupied housing). In addition, several variables on the supply side are included, such as the national real construction cost, and the local vacancy rate to reflect the existing supply of housing. Finally, a full set of year and municipality fixed effects are included, the former to capture time-invariant municipal characteristics and the latter to absorb any common shocks (e.g., a crisis at the national/global level). The dynamic model is estimated using annual data for 94 Danish municipalities over 2001–12 (Table 1 provides summary statistics). As is well known, the correlation between the municipality fixed effects and the lagged dependent variable could give rise to dynamic bias especially in “small T, large N” type of panels; thus, system Generalized Method of Moments (GMM) is used to mitigate this bias (e.g., Arellano and Bond, 1991; Arellano and Bover, 1995).

**Table 1. Denmark: Summary Statistics**

<i>Variable</i>	<i>Obs</i>	<i>Mean</i>	<i>Std. Dev.</i>	<i>Min</i>	<i>Max</i>
Real house prices (annual chg, %)	1,047	2.2	10.9	-23.1	45.6
Real household disposable income (annual chg, %)	1,047	1.5	2.9	-12.9	16.8
Aged 25-44 population (annual chg, %)	1,047	-1.2	2.9	-10.1	71.7
Vacancy rate (annual chg, %)	1,047	5.3	12.4	-67.5	82.9
Real mortgage rate (annual chg, percentage points)	1,047	-0.4	1.0	-2.3	1.8
Real construction cost (annual chg, %)	1,047	0.6	1.6	-1.7	4.6
Population density (thous. people per squared km)	94	0.6	1.5	0.0	12.1
Elasticity of housing supply	69	2.1	0.8	0.7	4.9

Sources: Statistics Denmark and Fund staff calculations.

**13. Estimation results indicate a significant role for supply conditions in shaping house price developments** (Table 2). Results from four models are reported: a baseline model estimated using Ordinary Least Squares (OLS, column 1) or GMM (column 2), an augmented model including supply constraint variables (either population density—column 3; or supply elasticity—column 4). In models 3 and 4, the measure of local supply constraint is interacted with two demand ‘shocks’, i.e., changes in the mortgage rate or real disposable income, to test whether house prices in more constrained locations respond more to changing demand. Results indicate that, subjected to a reduction in mortgage rates or an increase in disposable income, housing prices increase more strongly in cities with higher population density or less elastic supply. In other words, inelastic supply of housing contributes to magnify the impact of shocks to housing demand. Other variables also mostly behave as expected. On the demand side, stronger house prices are most robustly associated with higher disposable income, whereas the effects of population growth and mortgage rates have the correct signs but are not always statistically significant. On the supply side, higher

<sup>4</sup> We use the interest rates that mortgage institutes charge households on housing loans (effective rates including fees) from Statistics Denmark.

costs of construction nation-wide feed into local increases in house prices, as does a drop in the local vacancy rate.

**Table 2. Denmark: Determinants of Local House Price Growth**

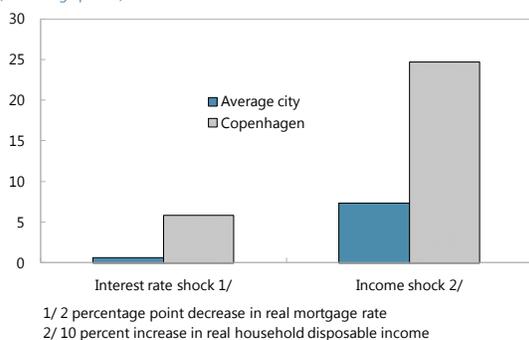
VARIABLES	(1) OLS	(2) GMM	(3) GMM	(4) GMM
Lagged real house price growth	-0.063 [0.049]	-0.539 [0.340]	-0.517 [0.323]	0.057 [0.402]
Real mortgage rate (change)	-1.154 [0.426]***	-0.194 [0.793]	-0.303 [0.752]	-1.354 [0.863]
Real disposable income p/c (change)	0.642 [0.159]***	0.837 [0.228]***	0.730 [0.212]***	0.474 [0.236]**
Population growth (aged 25-44)	0.150 [0.089]*	0.170 [0.130]	0.167 [0.122]	0.153 [0.083]*
Real construction cost (change)	2.178 [0.250]***	4.163 [1.430]***	4.067 [1.363]***	1.832 [1.574]
Vacancy dwellings per household (change)	-0.069 [0.020]***	-0.054 [0.022]**	-0.043 [0.022]**	-0.049 [0.029]*
Population density			-0.317 [0.222]	
Mortgage rate*Density			-0.442 [0.099]***	
Income growth*Density			0.296 [0.104]***	
Estimated supply elasticity				0.517 [0.407]
Mortgage rate*Elasticity				0.601 [0.303]**
Income growth*Elasticity				-0.359 [0.108]***
Observations	1,047	1,047	1,047	754
R-squared	0.621	--	--	--
Number of municipalities	94	94	94	68
Hansen test (p-value)	--	0.0795	0.159	0.347
AR(2) test (p-value)	--	0.106	0.135	0.958
Number of instruments	--	19	22	22

Sources: Fund staff estimates.

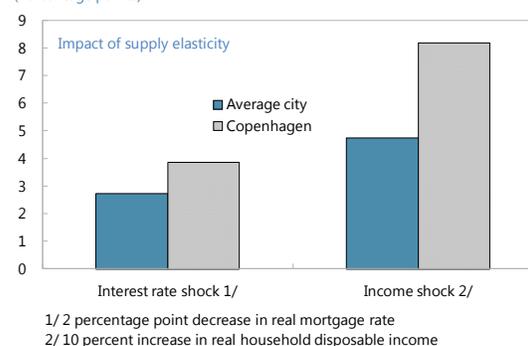
Notes: Dependent variable is annual growth rate of real house prices. The estimation sample consists of 94 Danish municipalities over the period 2001-2012. A full set of municipality and year fixed effects are included. Estimation method (specifications 2 to 4) is system GMM. Lag of the dependent variables and income growth are treated as endogenous, and instrumented using lags 2 to 4. Robust standard errors in brackets. Statistical significance at \*\*\* 1%, \*\* 5% and \* 10%.

**14. An example can further illustrate the economic impact of supply constraints.** In a simulation, we apply the estimated coefficients to demand shocks of economically meaningful size, which allows us to gauge the potential impact of supply constraints on prices. We experiment with two types of one-off shocks: (i) a 2 percentage point reduction in the real mortgage rate; and (ii) a 10 percent increase in real household disposable income. The applied interest rate reduction is approximately equivalent to the observed change in the real mortgage rate between 2004 and 2008 in Denmark, and the income shock is roughly comparable to the increase in disposable income in Copenhagen city between 2003 and 2006. We then compare the estimated response of house prices to these shocks in markets with different supply conditions, measured by either population density (model 3) or our estimated supply elasticity (model 4). Subjected to the interest rate shock, house prices would increase by 5 percentage points more in Copenhagen compared to a city with average population density, and 17 percentage points more if subjected to the income shock. If supply constraint is measured by the supply elasticity, the differential price responses between Copenhagen and the average city are somewhat smaller, 1.2 and 3.4 percentage points respectively. The stylized example highlights the importance of being able to adjust the housing stock to different demand conditions, if large run-ups or reversals in prices are to be avoided.

**Impact of Population Density on Real House Prices Growth**  
(Percentage points)



**Impact of Supply Elasticity on Real House Prices Growth**  
(Percentage points)



Source: Fund staff estimates.

## E. Conclusion

**15. Supply conditions matter for house price developments.** The analysis above highlights the often-underestimated role of housing supply constraints in shaping local house prices in Danish cities. Cities such as Copenhagen where the stock of housing is relatively inflexible and responds slowly to changes in housing demand could see higher price growth, *ceteris paribus*. We demonstrated in a simulation that the potential price impact of supply constraint can be economically significant.

**16. Addressing the risks from elevated house prices in certain Denmark's cities requires a multi-pronged approach, including relaxing supply constraints in pressured areas.** While natural land constraints are difficult to overcome, distortions in the housing markets could be reduced to alleviate the supply shortage in high-stress urban areas such as Copenhagen. For example, there is scope for relaxing zoning regulations in certain areas. In addition, reducing rental

## DENMARK

controls to allow freely determined rents to apply to a larger fraction of the housing stock, and creating the incentives for municipalities and/or private developers to put land to good use would also be helpful. This is particularly relevant in the current juncture, given the low interest rate environment as well as the recent influx of asylum seekers putting additional pressure on the demand for housing.

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# MACROPRUDENTIAL POLICIES IN DENMARK<sup>1</sup>

Despite the moderate recovery, house prices have risen strongly. Given high household debt and some specific features of Danish mortgages (in particular, a high share of variable rates and interest only loans), financial stability concerns could soon be emerging if rapid house price growth continues. Macroprudential policies can help contain risks for households, the financial system, and the broader economy, but they should be carefully calibrated to avoid an undue drag on growth. In this paper, we use a general equilibrium framework to study the impact of different macroprudential tools. Our tentative results suggest that macroprudential policies generally have limited impact on the real economy, while the effect on household debt can be substantial.

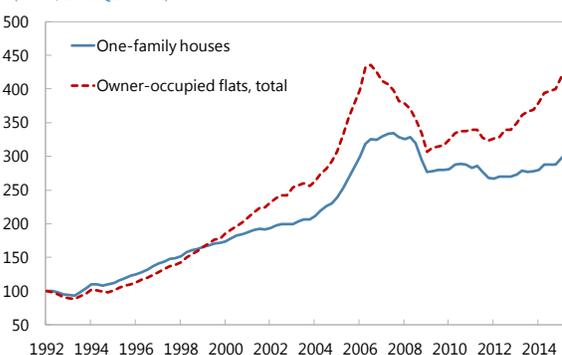
## A. Introduction

### 1. The Danish economy is gradually recovering from the global financial crisis.

Denmark was hard hit by the crisis, which coincided with the puncture of a local housing bubble during which average house prices fell by 20 percent between 2007 and 2009. As a result, residential investment has stagnated and a significant share of households is still re-building their balance sheets. In this environment, growth has been relatively weak in recent years though a modest recovery has been underway since 2014.

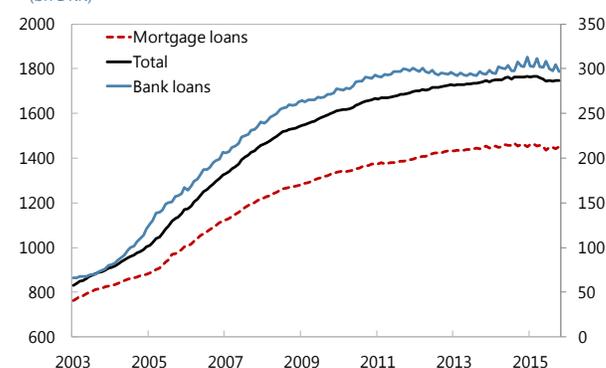
**2. Yet, house prices have risen strongly in recent years and household debt remains at a high level.** The continuing decline of interest rates, demographic factors, relatively healthy household disposable income growth, and—quite possibly—self-fulfilling price dynamics have driven up house prices again. Indeed, the price of owner-occupied apartments has almost reached its precrisis peak in nominal terms, though the price for one-family houses still remains well below its peak. Household debt has also been gradually increasing in nominal terms. And although the household debt-to-income ratio declined about 60 percentage points over 2008–14, it has started to rise again in 2015Q4.

**House Prices**  
(Index, 1992Q1 = 100)



Sources: Danmarks Nationalbank.

**Lending to Households for Housing Purposes**  
(bn DKK)



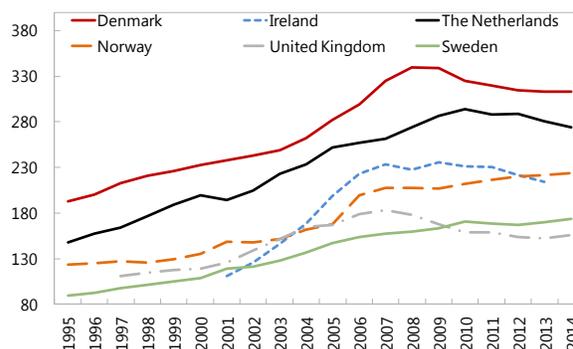
Sources: Danmarks Nationalbank.

<sup>1</sup> Prepared by Jiaqian Chen.

### 3. Rising house prices and high household debt are creating financial stability concerns.

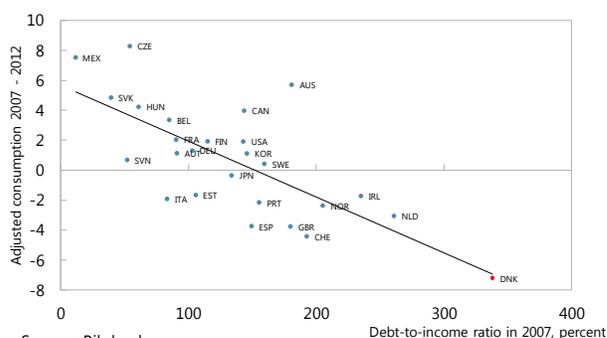
Banks and mortgage institutions have substantial direct exposures to the housing market. Their total lending to households for housing purposes amounts to approximately 90 percent of GDP (just under Dkr 1,750 billion). Moreover, the change in housing wealth has a considerable impact on private consumption, as indicated by Denmark's own experience. The last crisis also underscored the positive correlation between household leverage and sensitivity to shocks (Andersson, 2014). The rapid increase in house prices is again opening a positive valuation gap, especially in major cities, increasing the risk of another correction in the housing market further down the road. Importantly, credit booms and high level of household debt are associated with a higher probability of crises, deeper recession, and slower recovery (Schularick and Taylor, 2012; and Jorda and others, 2013) When this risk materializes, the impact on the macroeconomy could be even higher than the previous crisis since the recovery has been a relatively weak one.

**Households' Debt-to-Disposable Income**  
(percent)



Sources: Riksbank.

**Relationship Between Debt-to-Income Ratio and Consumption Growth between 2007 and 2012 1/**



Sources: Riksbank.

1/ Adjusted consumption growth has been calculated following Floden (2014).

**4. In view of the emerging risks, macroprudential policies need to play a primary role in safeguarding financial stability.** Monetary policy is fully dedicated to maintaining the peg with the euro (which has the side effect of a very low imported interest rate that likely adds fuel to house price increases), while fiscal policy adjustment should be calibrated to manage the broader economic cycle (which does not call for any sharp tightening at present). This leaves macroprudential policy as the main instrument to preserve financial stability, especially over the short run. A more stable housing market (i.e., less volatile house prices and household debt) would also contribute to smoother economic cycles, supporting other policies.

**5. However, macroprudential policies need to be carefully calibrated to avoid putting a drag on growth.** Any macroprudential measures that effectively impact credit and house price growth would inevitably also affect the macroeconomy. As the Danish economy is still recovering from the last crisis, new measures must be carefully calibrated to balance the benefits of reduced financial stability risks against any negative short-run impact on growth.

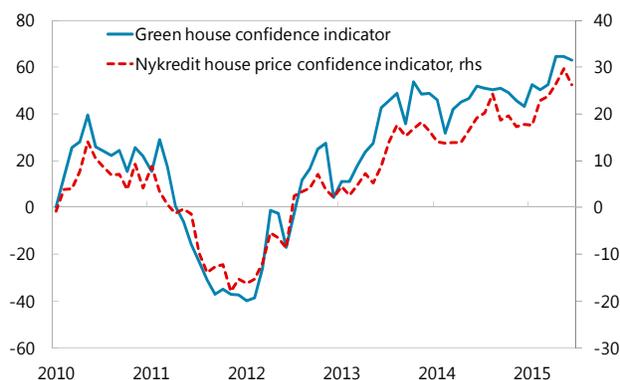
**6. In this paper, we analyze the impact of macroprudential policies in a general equilibrium framework.** This allows us to assess the impact of these policies not only on household debt, but also on broader macroeconomic variables, such as consumption.

**7. The paper is organized as follows:** Section B briefly describes the Danish housing market. Section C discusses the model and its calibration. Section D presents the model simulations. Finally, section E concludes with a discussion of policy implications.

## B. The Danish Housing Market—an Update

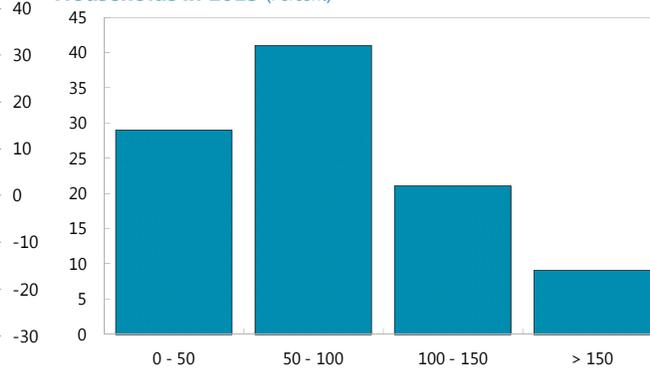
**8. Prices for both single family houses and owner-occupied flats have been increasing.** In mid-2015, prices for single family houses had risen by about 6 percent in real terms compared to a year earlier and by some 12 percent when compared to the market trough in 2010. However, prices have been rising faster in selected segments of the market, e.g., for Copenhagen, the increases since last year and since the trough were 13 and 43, respectively, while they were 12 and 33 percent for owner-occupied flats. Moreover, house price expectation indicators suggest the increasing trend in house price is most likely to continue.

**House Price Expectations**  
(Index)



Sources: Nykredit, Greens Analyseinstitut for dagbladet Borsen, and fund staff calculations

**Distribution of Loan-to-value Ratios for Indebtedness**  
Households in 2013 (Percent)



Sources: Danmarks NationalBank

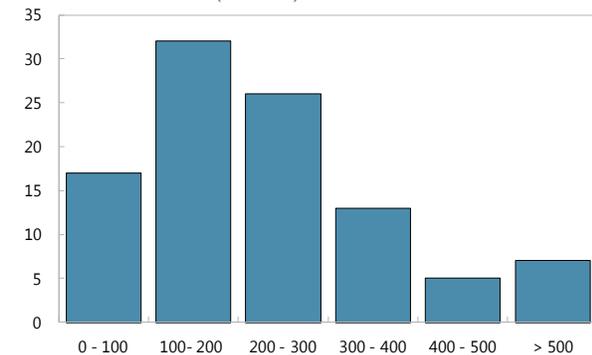
**9. Sizable pockets of vulnerable households remain.** The loan-to-value (LTV) ratio for the aggregate mortgage stock has fallen by about 5 percentage points from its peak, to about 55 percent in 2015. However, over 30 percent of indebted households have a LTV ratio above 100 percent. Similarly, at 12 percent, the share of households with a debt-to-income (DTI, defined as aggregate household debt as a share of income) ratio above 400 percent is high. Moreover, the share of families with both high LTV and DTI ratios remains above the level in 2007 suggesting a significant share of households are vulnerable to shocks.<sup>2</sup> Moreover, the LTV cap, currently at 95 percent, suggests that highly indebted households could borrow more as house prices increase.

**10. Variable rate mortgages account for a majority of the existing mortgage loans.** The share of variable rate mortgages increased by 38 percentage points before reaching a peak of 66 percent at end-2014. More recently, however, households have been increasingly opting for fixed

<sup>2</sup> High debt households are defined as families whose total debt exceed the value of their home and constitutes at least four times their annual gross income.

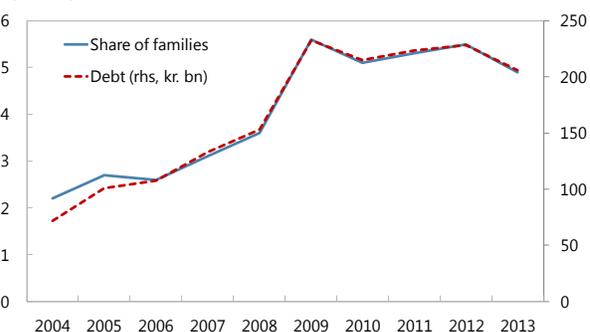
rate loans. Besides locking in historically-low interest rates, one reason for this trend is the increasing differentiation of administration margins, which has made fixed rate mortgages more attractive. Still, 75 percent of the families with high debt have variable rate mortgages, making them particularly vulnerable to an increase in interest rates.

**Distribution of Debt-to-income Ratios for Indebtedness Households in 2013 (Percent)**



Sources: Danmarks Nationalbank

**Share of Families with High Debt and Their Debt level 1/ (Percent)**

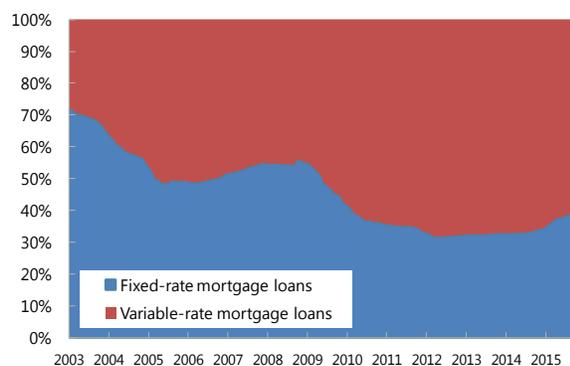


Sources: Danmarks Nationalbank

1/ High debt households is defined as families whose total debt exceeds the value of their home and constitutes at least four times their annual gross income.

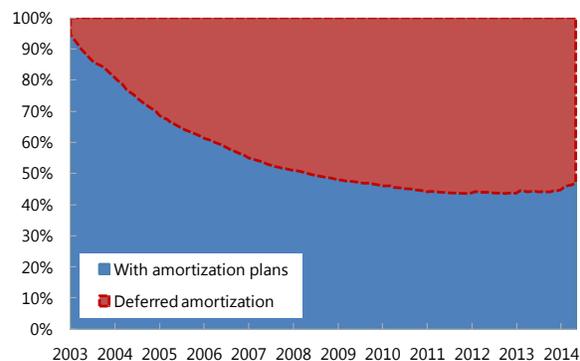
**11. The share of interest only mortgages has increased significantly.** Only a decade ago, almost all of the mortgage-credit loans had amortization plans. Since then, however, a greater number of households have opted for deferred amortization loans with variable interest rates, including with a view to optimize the benefits of interest tax deductibility. In 2015H1, variable rate loans with deferred amortization accounted for 42 percent of mortgage lending to households. This ratio increases to about 55 percent if fixed rate deferred amortization mortgages are also included. In order to maintain a good lending standard in the low interest rate environment, mortgage banks require the borrower to be able to service a 30-year fixed rate loan with amortization when granting deferred amortization loans. However, in the current environment, this means that a mortgage bank will effectively grant a variable rate, interest-only loan once a borrower is able to service a loan with a fixed rate of 3 percent.

**Share of Fixed and Variable Mortgages**



Sources: Danmarks Nationalbank.

**Household Mortgage Debt**

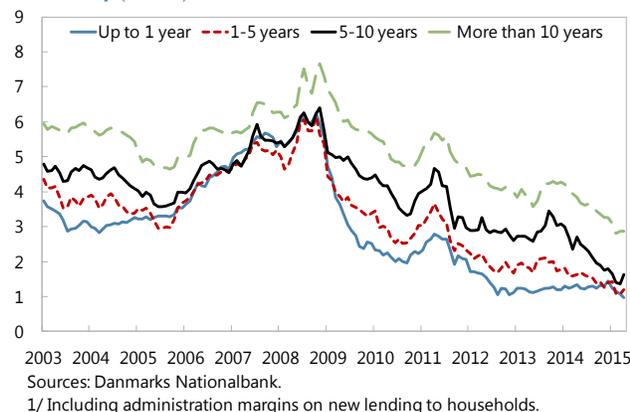


Sources: Danmarks Nationalbank.

**12. The very low policy rate has to great extent been passed through to mortgage borrowing costs.** At the beginning of the year, mortgage bond yields fell below zero for bonds with a maturity of up to three years. Despite mortgage banks having raised their administration margins, borrowing costs have fallen to the lowest level since 2003, with the cost of a 10-year fixed rate mortgage at only 3 percent in mid-2015.

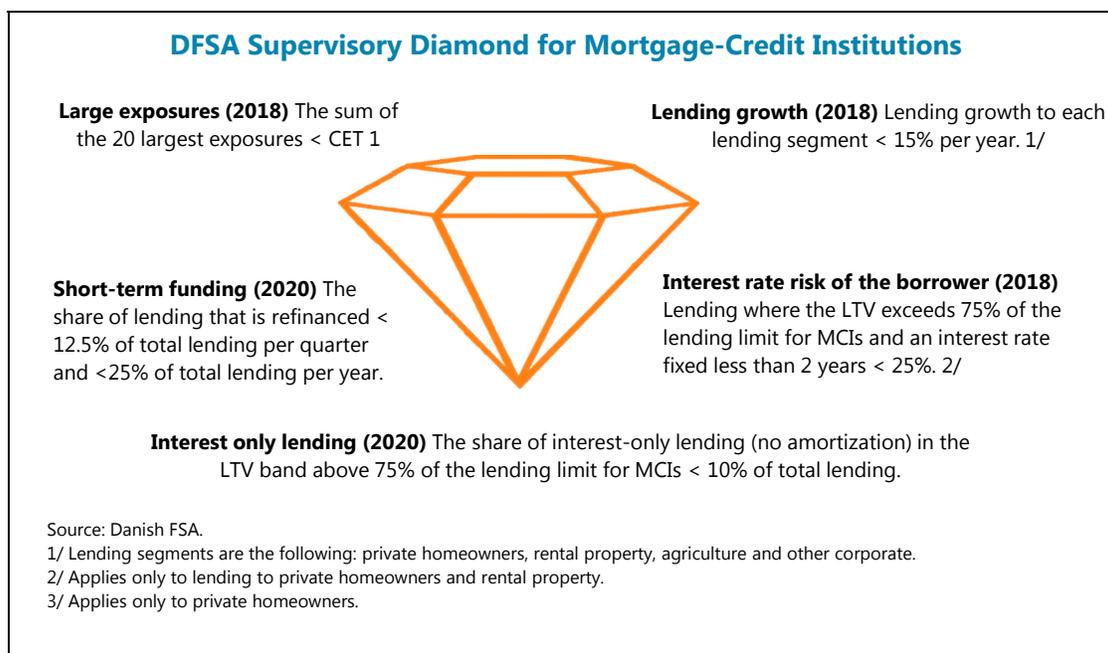
**13. Tax policy is also providing incentives for debt financed house purchases.** Housing taxes remain largely unchanged over time as the property tax has been frozen in nominal terms since 2002. Moreover, there is a cap on year-on-year increases in land tax in the form of a regulation ratio. As a result, the effective tax rate varies across different regions in Denmark, with areas experiencing higher house price increases sees the lower increase in property taxes. Moreover, mortgage interest payments are tax deductible, currently at 33.6 percent.<sup>3</sup> This provides an incentive to households to finance a house purchase with debt and allows them to borrow more by reducing the effective borrowing cost.

**Mortgage Banks' Average Interest Rates by Interest Rate Fixation 1/ (Percent)**



**14. The authorities have recently taken welcome steps to strengthen mortgage lending standards.** A minimum down payment requirement of five percent for new mortgages was introduced. In addition, the authorities have issued guidelines—"Seven Best Practices"—for banks in areas with rapid house price increases to strengthen their risk management practices. Moreover, the FSA has introduced the supervisory diamond for mortgage-credit institutions, which was introduced at the end of 2014, and is being phased in over a number of years.

<sup>3</sup>The tax value of capital income exceeding DKr 50,000 per person is gradually reduced by 1 percentage point a year until 2019 to a rate of 25.6 percent.

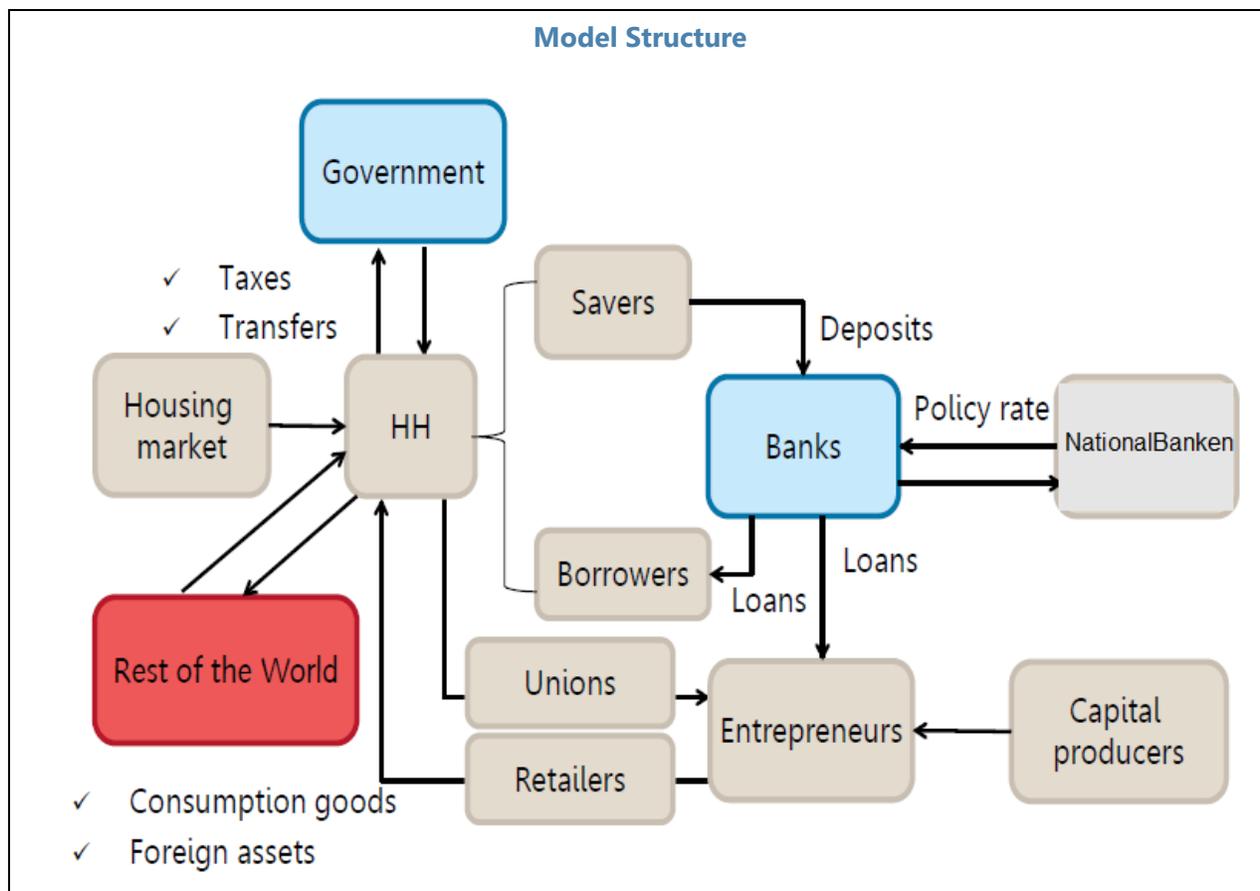


## C. The Modeling Approach and Calibration

**15. To analyze the effectiveness of macroprudential policies, while considering also the impact on the real economy, we use a DSGE model based on Chen and Columba (2016).** The model features a small open economy framework with financial frictions, an imperfectly competitive banking sector, and a selection of macroprudential tools. To adapt the original model to the Danish policy framework, we have modified the monetary policy rule so that the target of the central bank is to maintain nominal exchange rate stability. In addition, we have introduced a property tax into the model. The model can be used to analyze a range of possible instruments including loan-to-value caps, amortization requirements, tax deductibility of mortgage interest payments, property taxes, and mortgage risk weights.

**16. The model features a monopolistic banking sector and a range of macroprudential instruments.** The modeled world consists of two economies: home and foreign. The home economy is populated by two types of households—patient and impatient—and entrepreneurs. Households consume, work and accumulate housing (the supply of which is fixed), while entrepreneurs produce a homogenous intermediate good using physical capital bought from capital-goods producers and labor supplied by households. Agents (households and entrepreneurs) have different degrees of time preference (“patience”) reflected in different discount factors for their future utility. The heterogeneity in agents’ discount factors provides a simple way to generate financial flows in equilibrium: patient households (“savers”) purchase a positive amount of saving assets (deposits at domestic banks and foreign bonds) and do not borrow, while impatient households (“borrowers”) and entrepreneurs borrow from the domestic banking system. Impatient households can borrow up to a fraction, at 95 percent, of the value of new housing acquisitions each period. We include an

amortization requirement by assuming that the impatient households must repay a fixed fraction of the loan principal each period. We defer reader to Chen and Columba (2016) for a more detailed discussion of the model.



**17. We calibrate the model to resemble the Danish economy, partly using estimated parameters from the literature.** Since the literature on estimated DSGE models for Denmark is limited, however, we rely in particular on Pedersen and Ravn (2013). For example, we set the LTV cap for new mortgages at 95 percent, and an average amortization period of mortgages to 40 years. We set the minimum bank risk weighted capital ratio to 12 percent, matching the capital requirement for Danish banks in 2019. For price and wage adjustment costs, we calibrate the adjustment factors such that they are in the range suggested by Pedersen and Ravn (2013). The calibrated model closely resembles key features of the Danish economy. For instance, the model implies consumption and investment shares of about 50 and 20 percent of GDP, respectively. The steady state debt as a share of the value of the housing stock (i.e., LTV ratio for the aggregate economy) is about 60 percent.

#### D. Policy Exercises

**18. We use the framework to study the effectiveness of macroprudential policies and assess their impact on the real economy.** We focus on three macroprudential instruments: (i) tax

deductibility of mortgage interest payments; (ii) amortization requirements (or limits on deferred amortization loans); and (iii) loan-to-value caps. Given that the model has more than 100 variables, we focus the discussion on the key ones.

**19. Specifically, we compare the steady states of the economy after changing the combination of macroprudential policy instruments.** We describe the transition paths of the key variables from one steady state to another. For example, a permanent reduction in tax deductibility of mortgage interest payment would tighten borrower’s liquidity conditions and change the relative price between consumption goods and housing investment (making consumption goods cheaper). Such a change would affect the borrower’s behavior, which would in turn interact with the savers, entrepreneurs, banks and other agents in the model, until a new equilibrium is reached.

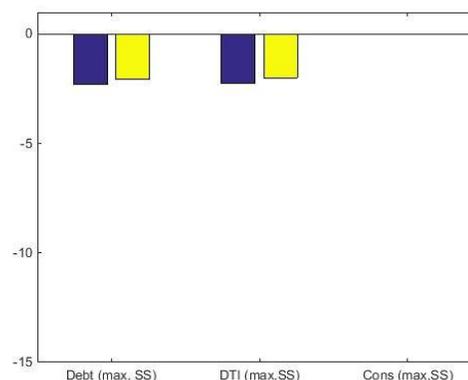
### Tax Deductibility of Mortgage Interest Payments

**20. A reduction in tax deductibility has complicated, but eventually negligible effects on consumption.** As discussed above, a reduction in the tax deductibility of mortgage interest increases the cost of servicing mortgage debt, thereby tightening a household’s budget constraint—a negative income effect. Moreover, such a reduction would make debt-financed house purchases more costly relative to goods consumption—a substitution effect. The two effects have opposing effects on household consumption. The former suggests a reduction in tax deductibility *lowers* household’s consumption, while the substitution effect implies that households consume *more* as the relative price change has made consumption goods cheaper. The text figure illustrates the impact of a 5 percentage points reduction of tax deductibility (i.e., a reduction to 28.6 percent):

- **Short run.** The income and substitution effects lower borrowers’ demand for housing, with house prices falling by 0.5 percent in the near term. However, borrowers’ consumption increases in the short run due to the substitution effect. Moreover, the model assumes the government redistributes the savings raised from the reduction in tax deductibility to both savers and borrowers. This helps to alleviate some of the impact from the negative income shock to the borrowers. Savers would increase their housing investment as house prices decline, but they also benefit from the higher transfers leading to higher consumption. Overall, consumption, output, and inflation rise slightly over the short run.

- **New steady state.** Borrowers’ debt falls by about 2 percent, with a similar change in the debt-to-income (DTI) ratio. Their consumption increases by 0.1 percent, but housing investment falls by 2 percent. Savers’ consumption also increases in this case by 0.05 percent, driven by higher

#### A 5 Percentage Points Reduction in Tax Deductibility



Note: Figure depicts maximum impacts on household mortgage debt, DTI and consumption (Cons) following a permanent reduction in mortgage tax deductibility. And changes in the three variables in the new steady state (tax deductibility = 28.6 percent) compared with the baseline (tax deductibility = 33.6 percent).

transfers as explained above. The latter would be sufficient to offset the impact of the decline in bank profits such that a decline in saver's consumption is avoided. How the government redistributes the "savings" from the reduction in tax deductibility is important, and it can be shown that savers' consumption would decline if the government does not fully redistribute the "savings" from reducing tax deductibility.

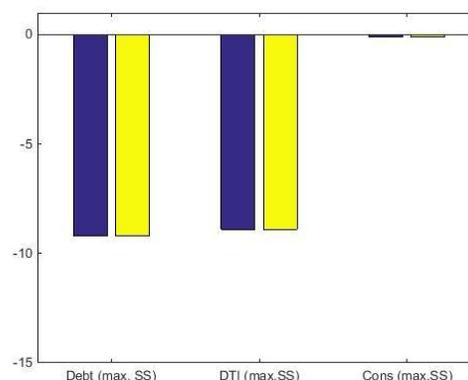
## Loan-to-Value Cap

**21. A cap on the LTV ratio constrains how much households can borrow and has a substantial impact on debt levels.** House prices would fall as borrowers' housing demand is reduced by their more limited ability to borrow. Falling house prices implies a lower value of housing collateral, thus it amplifies the effect of a tightening of the LTV cap. In what follows, we consider a scenario in which the LTV cap is reduced by 5 percentage points to 90 percent.

- **Short run.** Borrowers' consumption falls sharply by 5 percent immediately after the shock. Savers' consumption decreases as well for two years after the shock, although by less. This is partly driven by a decline in the deposit rates as the lower stock of mortgages reduces bank profitability. Altogether, the tightening of the LTV cap has a contractionary short-term effect on the economy, lowering aggregate consumption by 1.5 percent one year after the shock.

- **New steady state.** Borrowers' mortgage debt declines by 7 percent, in part because house prices fall by 2 percent. The relatively modest decline in house prices reflects to some extent the significant price elasticity of savers' demand for housing compensating for the decline in borrowers' demand (as supply relative to population is assumed to be fixed). Notably, borrowers' consumption of goods will be permanently higher by about 0.2 percent in the new steady state, as their debt service burden is lower, partly offsetting the decline in their consumption of housing services. But savers' consumption would decline during the transition, and be 0.4 percent lower in the new steady state. This result is driven by bank profits falling by about 2 percent as banks cut back on mortgage lending. Lower bank profits also imply that banks deleverage, cutting loans to firms by about 0.8 percent implying lower investment and production. As a result output will be about 0.2 percent lower in the new steady state.

### A 5 Percentage Point Reduction in LTV



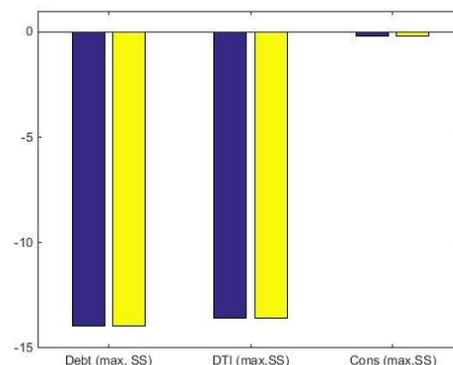
Note: Figure depicts maximum impacts on household mortgage debt, DTI and consumption (Cons) following a permanent reduction in LTV cap. And changes in the three variables in the new steady state (LTV= 90 percent) compared with the baseline (LTV= 95 percent).

## Amortization Requirement

**22. An amortization requirement would have the strongest impact on debt.** With the introduction of amortization requirements, a portion of the mortgage principal must be repaid each period, in an amount set by the amortization plan in the loan contract. This then sets the maturity of the loan. We examine the effects of reducing the maturity of new loans from 40 years to 35 years.

- **Over the short run.** The model suggests that borrower's consumption would fall by a very small amount (i.e., by 0.2 percent 2.5 years after the shock). Overall, a tightening of the amortization requirement has almost no impact on growth.
- **In the new steady state.** Borrowers' debt will fall by about 15 percent, with households' DTI ratio falling by the similar amount, and house prices down by 0.5 percent. In addition, borrowers' housing stock will be about 1 percent lower in the new steady state. Borrowers' consumption will be about 1.5 percent higher permanently. Savers' consumption will decline by 0.4 percent. This again reflects a lower bank profits (by over 5 percent) leading to a decline in credit to firms of more than 1.5 percent. As a result, output is lowered by about 0.4 percent.

### A Reduction in Required Amortization by Five Years



Note: Figure depicts maximum impacts on household mortgage debt, DTI and consumption (Cons) following a permanent reduction in amortization requirement. And changes in the three variables in the new steady state (amortization = 35 years) compared with the baseline (amortization = 40 years).

## E. Conclusion

**23. This paper provides some tentative estimates of the potential effects of tightening macroprudential policies in Denmark.** The results are intended to provide food for thought for policymakers when thinking about macroprudential policy formulation. A few results stand out. First, the overall impact from macroprudential policies on the real economy appears limited, while the effect on debt levels can be significant. Second, out of the various modeled policies, amortization requirements seem to have the strongest impact on household debt, suggesting the importance of limiting the growth of deferred amortization mortgages. The results are indicative and the usual caveats apply. Mainly, the paper provides a basic framework for further research, including possible welfare analysis that enables the policymakers to understand better the trade-offs between household's ability to borrow and consume housing, and their vulnerability to financial shocks. For example, Chen and Columba (2016) show on the basis of a similar framework for Sweden that a combination of macroprudential tools can achieve higher welfare than relying on a single measure.

## References

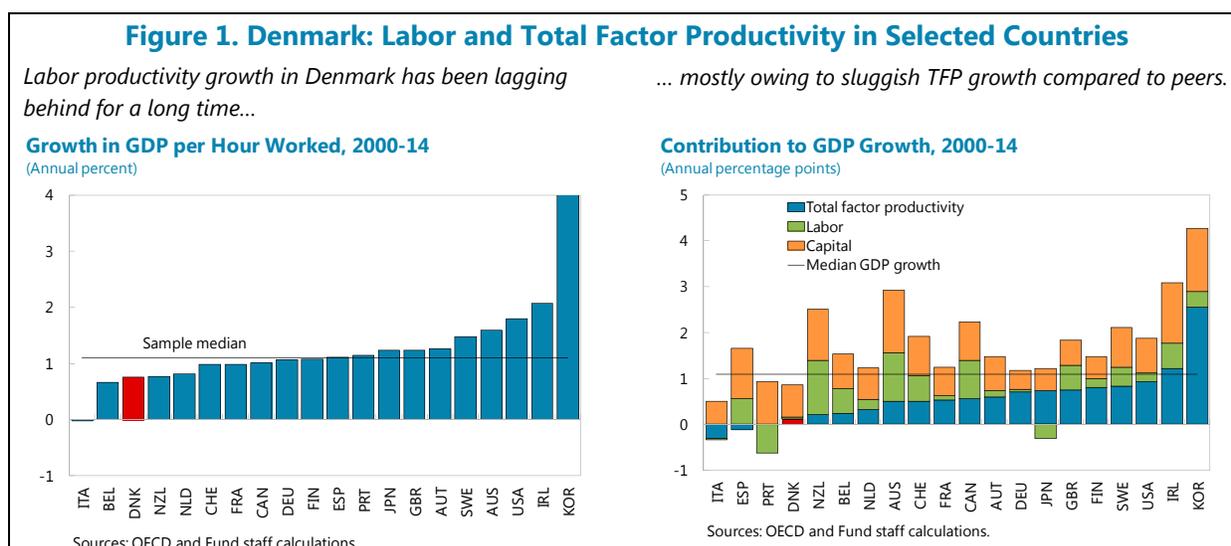
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# PRODUCT MARKET REFORM AND FIRM PRODUCTIVITY IN DENMARK<sup>1</sup>

Productivity growth in Denmark has lagged that in European peers for an extended period, weighing on GDP growth. Whereas labor and capital markets are relatively flexible already, there is scope for further relaxing product market regulation in some network sectors and retail trade. The paper uses firm-level data to assess the impact of product market reforms in these sectors on firm productivity in Denmark both in the deregulated markets and in downstream sectors. The results point to potentially large productivity gains for the entire economy.

## A. Background

**1. Denmark's productivity growth has lagged behind most of its peers.** During 2000–14, growth in labor productivity has been weaker in Denmark than in other OECD countries (Figure 1). Much of this is driven by sluggish growth in total factor productivity (TFP). For other countries, the TFP contribution to GDP growth relative to other factors of production has been much higher. Previous analyses have also pointed to weak productivity growth in Denmark as an important factor dragging down economic performance (e.g., Copenhagen Economics, 2013a; OECD, 2014a).

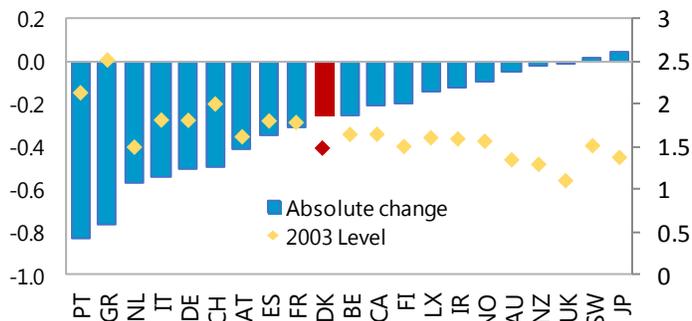


<sup>1</sup> Prepared by Nan Geng, Giang Ho, and Rima A. Turk. We would like to thank Mico Mrkaic (IMF, 2016a) for sharing with us the code to extract Orbis data and calculate firm productivity.

**2. Over the past years, product market regulations have been relaxed to enhance productivity growth.**

Product markets have been liberalized substantially in a number of sectors, as reflected in an improvement in the OECD’s Product Market Regulation (PMR) indicator over 2003–13. In the network sectors, public ownership was reduced in varying degrees and at different speeds, contributing to significant economic gains for the entire economy (Copenhagen Economics, 2013b).<sup>2</sup> In the retail sector, the gradual liberalization of laws regulating opening hours since 2012 has also had an important impact on productivity growth (Copenhagen Economics, 2013c).<sup>3</sup> These product market reforms and other structural reforms—including the strengthening of education and labor market institutions and higher R&D investment—are positively reflected across many business environment indicators on which Denmark scores relatively high (IMF, 2014).

**Product Market Regulation: Change 2003-13. 1/**

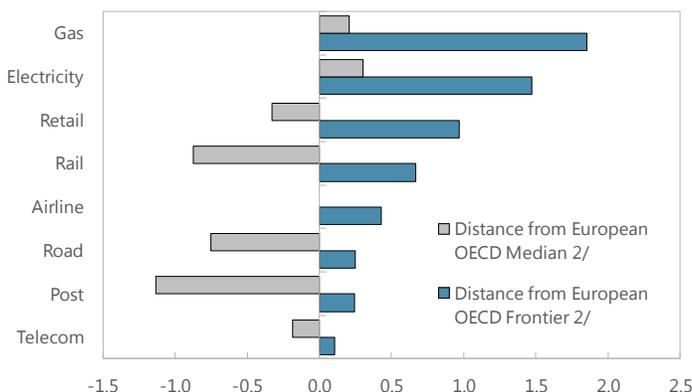


Sources: OECD and Fund staff calculations. 1/ A higher level of PMR indicates more regulation. A negative change implies less regulations.

**3. However, a regulatory gap remains between Denmark and the OECD frontier.**

To assess the regulatory burden in Denmark relative to peer countries, we use OECD indicators (scaled between 0 and 6) of PMR in individual sectors. While these OECD indicators are not perfect measures of the state of regulation in individual countries, they provide a useful cross-country perspective and are arguably the best measure available for international comparisons of regulation in network sectors and retail trade.<sup>4</sup> A cross-country comparison on the basis of PMR indicators points to a sizable deregulation gap between Denmark and the OECD or European OECD frontiers, notably for the electricity, gas, retail, and rail sectors.<sup>5</sup> A breakdown of the PMR indicators provided by the OECD suggests that for the

**Product Market Regulation in 2013, Denmark vs. OECD 1/**



Sources: OECD and Fund staff calculations. 1/ European OECD frontiers are calculated as the averages for the three best European performers in OECD, which are very close to the OECD frontiers, except for road where it is much worse. 2/ A negative value implies less regulations.

<sup>2</sup> Network sectors include air transport, electricity, gas, post, rail, road transport, and telecom.

<sup>3</sup> The retail sector in Denmark can be divided into five subsectors: grocery, department stores, clothes and shoes, pharmacies, and others and repairs (Copenhagen Economics, 2013c).

<sup>4</sup> For instance, the electricity and gas sectors in Denmark have been liberalized, and the gap suggested by the OECD indicator seems possibly too large—although significant scope for further efficiency gains in these sectors remains.

<sup>5</sup> The OECD frontier is calculated as the average indicator of the best three countries for each sector, all of which are from the EU.

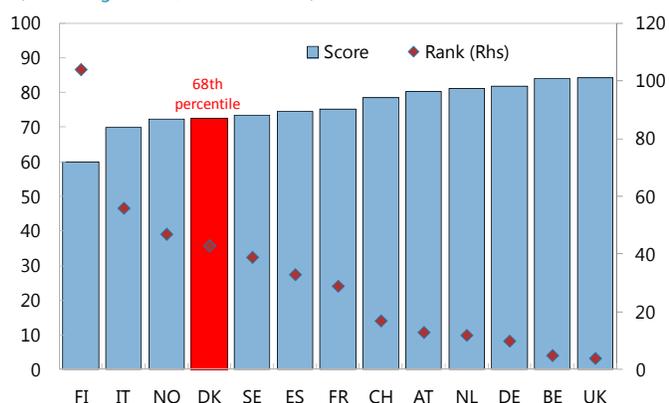
network industries the sizeable gap with the frontier is explained in particular by regulation pertaining to public ownership, vertical integration, and market structure.<sup>6</sup> For the retail sector, regulation in Denmark is most restrictive in areas of licensing, large outlets, protection of existing firms, shop opening hours, and price controls.<sup>7</sup>

#### 4. Product market regulations in Denmark can impede competition and may help explain low productivity growth.

Several studies have highlighted that anti-competitive regulations in Denmark effectively raise barriers to entry, thereby limiting competition and productivity growth (McKinsey, 2010; Copenhagen Economics, 2013a and 2013b). Insufficient competition between a small number of incumbents hinders business dynamics—e.g., inefficient firms are not forced out of business and existing stores are not able to achieve economies of scale. By removing barriers to competition (such as regulated prices, licensing requirements, or zoning restrictions), new entrants could intensify competition thereby putting pressure on firms to cut product prices and/or improve their quality and thus improve productivity. In this context, the report of the Productivity Commission—appointed in 2012 by the Government to investigate the slowdown in productivity growth—already highlighted that regulation in network sectors and retail trade needs that is not justified by other objectives to be reconsidered (OECD, 2014a).<sup>8</sup>

#### Intensity of Local Competition, 2015

(Score range: 0-100; 141 economies)



Sources: Global Innovation Index 2015 and Fund staff calculations.

**5. This paper uses firm-level data to estimate potential productivity gains from product market reforms in Denmark's regulated sectors.** Unlike previous productivity analyses that rely on aggregate indicators, this study uses firm-level data in a panel setting. It also goes beyond assessing the direct impact that reforms may bring to the regulated industries, as relaxing regulatory burden in those product markets may also reverberate on "downstream" firm productivity across the entire economy. This aspect of deregulation is receiving increasing attention in other advanced economies (IMF World Economic Outlook, April 2016b; Barone and Cingano, 2011; Bourlès and others, 2013; Lanau and Topalova, 2016), but it has been less explored in the context of Denmark. We find that relaxing product market regulation could significantly improve firm productivity in Denmark, and that the effect of reforms would be largest for smaller downstream firms. In a stylized

<sup>6</sup> The OECD PMR indicator for the network sectors covers five areas of regulation: public ownership, vertical integration, entry regulation, market structure, and price controls.

<sup>7</sup> In addition to the five areas listed, the OECD PMR indicator for the retail sectors includes promotions/discounts.

<sup>8</sup> Regulation may be in place to support other key policy objectives, e.g., the generation of electricity from renewable sources.

exercise, we estimate that closing half of the PMR gap between Denmark and the European OECD frontier would increase average firm TFP by 12 percent for the network industries and by 20 percent for retail trade.

**6. The rest of the paper is organized as follows:** Section B describes the state of product market regulation in the network and retail sectors in Denmark. Section C describes the data and empirical specification. Section D discusses the findings and conducts policy experiments. Section E concludes.

## B. Product Market Regulation in Network and Retail Industries

### Regulation in Network Sectors

**7. Network industries provide important services to the entire economy.** They use a delivery network as their main asset (e.g., transmission of electricity from generators to users, network of postmen, etc.) and they tend to be important suppliers to many other industries and consumers. Therefore, by ensuring high-quality products and services at competitive prices, well-functioning network industries could have significant beneficial impacts on the competitiveness of other Danish businesses.

**8. Substantial progress has been made in deregulating network industries in Denmark.** Deregulation of network industries in Denmark started early in the 1990s with the reduction of public ownership and has progressed well relative to peers. Sectors such as telecommunications, rail freight, and to some degree electricity were opened to more competition. Deregulation generated economic gains in terms of welfare, consumption, and employment while leading to significant spillover effects to the rest of the economy (Copenhagen Economics, 2005). Historically, the market in telecommunications was more open in Denmark than in other EU member states, the urban transport market started to open much earlier than in other countries, and significant progress was made towards opening the gas market. For electricity, the speed of market opening was slower than for other countries. Also, some steps were taken to open postal services, but much less was done in the area of passenger rail.

**9. Nevertheless, network industries in Denmark present scope for further deregulation.** Recent studies have identified the postal sector and transport services—notably passenger rail<sup>9</sup>—as having large potential for further deregulation. The energy sector also presents more potential (Copenhagen Economics, 2013a and 2013b; OECD, 2014a). To that end, the government has recently commissioned McKinsey & Company to analyze the utilities sector—including electricity, gas, water, waste water, and district heating—and estimate potential efficiency gains from improving

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<sup>9</sup> As in many other EU countries, the passenger rail system is mainly dominated by a state-owned company in Denmark, although the country has some experience with tendering since a few lines are operated by another supplier.

governance, consolidation, and regulation in these sectors. As for rail freight and telecommunications, there is little scope for more market opening.

**10. Productivity gains from network sector deregulation can be significant.** Network sectors hold potential for productivity growth resulting from regulatory changes (Copenhagen Economics, 2013a). The Productivity Commission had estimated the potential gain from increasing competition in the utilities sector at Dkr 3.3 billion by 2020, mostly in postal services and rail transport of passengers (Produktivitets Kommissionen, 2014). Similarly, estimates of productivity gains by Copenhagen Economics (2013b) from market opening in the network sectors are sizable, ranging from 2 percent for the electricity sector to 24 percent in telecom, 28 percent in postal services, and can be as high as 47 percent for rail freight. As for rail passenger liberalization, productivity and welfare gains can also be expected with the 2013 European Commission package that opens the sector to new entrants by 2019 (OECD, 2014a).

### Regulation in Retail Sectors

**11. The retail sector continues to face strong barriers to competition.** Despite the removal of restrictions on opening hours other than on public holidays and the possibility to open on Sundays since 2012, retail trade in Denmark remains subject to substantial restrictions (Copenhagen Economics, 2013c). For example, the Danish planning law constitutes a market entry barrier for foreign retail business models, including bans on outlets above a certain surface threshold that depend on location and strict rules concerning outlet locations in city and local centers (European Commission, 2015). These regulations are among the most restrictive in Europe and may inhibit investment in the retail sector, which is characterized by high concentration, high prices, and a low proportion of foreign companies.<sup>10,11</sup> The Productivity Commission recommended that ownership restrictions of businesses be removed as far as possible, with permission to establish larger stores, easing the rules regarding the location of shops, and freedom to establish pharmacies.

**12. The government's Growth Plan proposed reforms in several areas pointed out by the report of the Productivity Commission.** The Growth Plan 2014 comprised various measures to accelerate productivity growth in Denmark, including by strengthening the institutional framework for competition, streamlining business regulations, and lowering corporate income taxes (Danish Ministry of Business and Growth, 2014). However, it did not include action to address the barriers to competition in the retail sector such as permits to engage in commercial activity, specific regulations for large outlets, and zoning regulations that limit the location of stores and their size (OECD, 2014a; European Commission, 2016). To bring competition in line with best practice among EU countries,

<sup>10</sup> Prices are highest in the EU for categories of food, footwear and consumer electronics, the second highest for clothing and household appliances (European Commission, 2015).

<sup>11</sup> Foreign companies are only represented in the discount segment of groceries market and account only 12 percent of that sector (European Commission, 2015).

planning laws need to be liberalized and competition considerations need to be incorporated, while making information about the relevant laws and regulations also accessible to foreigner retailers.

**13. More recently, the government has proposed liberalizing the Planning Act to reduce barriers to entry and alleviate the regulatory burden in retail services.** The new Growth and Development Strategy proposed in November 2015 envisages removing the floor cap for stores selling books, electronic goods, clothes, and furniture in all cities, allowing them to better respond to competition from e-commerce foreign companies. Municipalities will be able to decide to what extent bigger and more productive grocery shops can be opened in different areas in Denmark. But the strategy does not provide the possibility to establish significantly larger grocery stores (hypermarkets or stores above 10,000 square meters) because of concerns that allowing such larger stores would reduce the geographic proximity to consumers of grocery retailers.

**14. The proposed measures could significantly improve conditions in the retail sector.** However, relaxing the planning rules also for larger grocery stores would boost productivity gains more, and contribute more substantially to lower prices and a broader choice for consumers (European Commission, 2016). The productivity gains of retail trade deregulation can be significant and even higher than those from deregulation of network industries. Copenhagen Economics (2013a, b, and c) estimate that the productivity gap between the Danish retail sectors and peers from 1995 to 2010 corresponds to a loss of DKK 12.5 billion—equivalent to about 1 percent of the average GDP over that period. They find that zoning regulation is the regulatory factor contributing most to poor productivity growth and that productivity in the grocery retail subsector alone could have been higher by 13 percent over that period without such regulation..

### C. Data and Empirical Specification

**15. The economic impact from product market reforms could go beyond firms in regulated markets.** The degree of regulation in network industries affects productivity of other firms through the quality and price of production inputs, producing ripple effects throughout the economy. Similarly, regulation in retail trade affects other sectors that rely on retail services as part of their production and distribution process through retail costs and (hence) final product prices. Indeed, a growing body of the literature shows that benefits from reducing anti-competitive regulation in network or retail industries extend beyond the immediate sector being liberalized.<sup>12</sup>

**16. We measure both the direct and indirect burden from PMR for all sectors in the Danish economy.** The OECD's PMR indicators for seven network sectors and for retail trade are used as measures of the *direct regulatory burden* to firms in these sectors (Box 1). In the analysis, regulation in those industries also indirectly affects firms in the downstream sectors. For example, a

<sup>12</sup> A number of papers have documented the presence of adverse effects from upstream inefficiencies using I-O linkages in a single country context (Arnold and others, 2011; Forlani, 2012; Correa-López and Doménech, 2014; Lanau and Topalova, 2016) and across OECD countries (Barone and Cingano, 2011; Bourlès and others, 2013).

manufacturer that relies more extensively on the use of electricity and gas would bear a heavier burden from regulation in the electricity and gas sectors, either through paying higher prices or enduring sub-optimal quality of services. We measure the *indirect regulatory burden* on all sectors that we henceforth refer to as *upstream PMR*, which is the downstream effect of product market regulation in upstream sectors. *Upstream PMR* combines the PMR indicator with an indicator of the intensity of network and retail usage calculated from Denmark's input-output table (Box 1). Thus, unlike the PMR indicators that cover the seven network industries and retail trade only, *upstream PMR* affects the entire economy to the extent that other sectors use inputs from network industries and retail trade.<sup>13</sup> In line with the literature where the effect of deregulation is found to differ across firms of different size, we also allow for the estimated burden from PMR to vary by firm size.<sup>14</sup>

**17. We calculate different measures of firm productivity using firm-level data from Orbis.**

Orbis is a commercial database, compiled by Bureau Van Dijk, which provides worldwide financial data at the firm level on value added, number of employees, and fixed assets, among other variables, allowing for the computation of firm-level productivity.<sup>15</sup> The Denmark sample consists of about 29,000 public and private firms and covers the period between 2010 and 2014, resulting in 71,374 firm-year observations.<sup>16</sup> We compute both labor productivity (i.e., real value added per worker) and three TFP measures for each firm using three different methodologies (Box 2).

**18. The following empirical specification is used to investigate the correlation between PMR and firm productivity:**

$$Y_{ist} = \beta * PMR_{st} + \gamma' X_{ist} + Z_t + D_s + D_r + \varepsilon_{ist}$$

Where  $Y_{ist}$  refers to the natural logarithm of firm productivity (either labor productivity or TFP),  $PMR_{st}$  denotes either the direct sector-level PMR indicator in the regulated sectors or the calculated indirect sector-level *upstream PMR* across all sectors,  $X_{ist}$  is a vector of firm-level control variables (e.g., leverage defined as the ratio of total debt to total assets and company age<sup>17</sup>),  $Z_t$  is the output gap to capture the economy's cyclical condition, and  $D_s$  and  $D_r$  are sector and region fixed effects.

<sup>13</sup> Although downstream spillover effects from product market deregulation in network sectors are likely to be higher than those deriving from deregulation in retail sectors, there is potential for improving both competition and productivity in retail if regulatory barriers are reduced. Whereas the channel from retail trade to other sectors is less clear, potential productivity gains could be sizable due to the high contribution of the retail sector to the economy and its relatively large productivity gap (see also Copenhagen Economics, 2013a).

<sup>14</sup> Forlani (2012) finds that small firms are most harmed by uncompetitive behavior in network industries in France, whereas the findings of Correa-López and Doménech (2014) for Spain indicate that large firms benefit most from deregulation.

<sup>15</sup> See Appendix I for a description of the sample and the procedure we implement to prepare the Orbis data for analysis.

<sup>16</sup> Data for pre-2010 years are sparse and thus are not used in the analysis.

<sup>17</sup> We classify firms across four age classes: start-ups, young, mature, and well-established (Appendix I).

We run the regressions by firm size class (i.e., micro, small, medium, and large) to allow for the impact of deregulation to vary for firms of different sizes.<sup>18</sup>

### Box 1. Measuring Direct and Indirect Regulatory Burdens

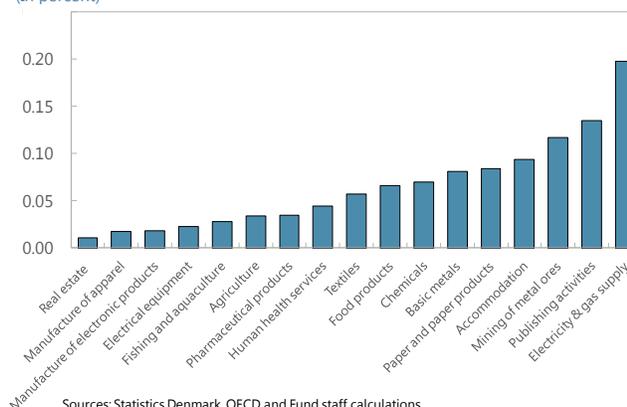
The OECD indicators of PMR are used to measure regulatory provisions in retail trade and the seven network sectors covered in the analysis (air transport, electricity, gas, post, rail, road transport, and telecom) over the sample period. The evaluation of the network sector-specific PMRs follows a bottom up approach, aggregating data on entry regulation, public ownership, vertical integration, market structure, and price controls. Retail trade sector regulation is similarly assessed by compiling evaluations of six dimensions, i.e. entry regulation, restrictions on shop size, protection of existing firms, regulation of shop opening hours, price controls, and promotions or discounts. The scale of the PMR indicators ranges from 0 to 6, with higher values indicating more regulation. The indicators are provided on a yearly basis for network industries but they are only available every five years in 2003, 2008, and 2013 for retail trade. The regulated network sectors and retail trade account for about 10 percent of total output in the economy.

From the Danish input-output table for 2012, we extract information on the use of inputs for each of the 87 NACE Revision 2 sectors as well as their output. The variation in input usage across industries called input intensity allows us to extend the direct regulatory burden in network sectors and retail trade to the entire economy, thereby capturing the indirect regulatory burden from upstream sectors on all firms. Using both the PMR indicators and input intensities, we follow Bourles and others (2013) to measure the indirect regulatory burden from regulation in network and retail industries on downstream sectors, which we refer to as *Upstream PMR*. More specifically, we aggregate PMRs and input intensities (from upstream regulated sectors) for each two-digit level sector in the economy as follows:

$$pstream\ PMR_{dt} = \sum_{u=1}^7 PMR_{ut} * Intensity_{du}$$

$PMR_{ut}$  is the direct regulatory burden for regulated sector  $u$  at time  $t$ , and  $Intensity_{du}$  refers to sector-specific input intensities of downstream sector  $d$  from the regulated sector  $u$ , measured as the units of regulated product  $u$  that are needed to produce one unit of final output in sector  $d$ . Thus,  $UpstreamPMR_{dt}$  measures the indirect regulatory burden that sector  $d$  is subject to at time  $t$ , calculated as the weighted average of the direct regulatory burden in regulated sectors and the sector-specific input intensities. The text figure below illustrates the level of *upstream PMR* from the seven network sectors and retail trade for selected two-digit-level downstream sectors in Danish economy. With varying input dependency on products from regulated sectors, all sectors in the economy are subject to upstream product market regulation from the seven network sectors and retail trade that ranges from 0.002 to 0.23.

**Upstream PMR (network industries and retail trade), selected sectors**  
(in percent)



Sources: Statistics Denmark, OECD and Fund staff calculations.

<sup>18</sup> We classify firms into four size classes: micro = 10 employees or fewer, small = 10 to 50 employees, medium = 50 to 250, and large = more than 250. Instead of running regressions by firm size class, we also try controlling for the logarithm of total assets; the results are qualitatively unchanged.

### Box 2. Measures of Firm-Level TFP

Three measures of firm TFP are computed for the analysis. First, an index number-based TFP measure is calculated as the Solow residual from a Cobb-Douglas production function with labor and capital as factors of production. For each 1-digit NACE sector, the labor and capital shares are obtained from the OECD STAN database. The Cobb-Douglas production function has the general form:

$$A_{ist} = Y_{ist} / [L_{ist}^{\alpha_s} K_{ist}^{1-\alpha_s}]$$

Where  $A_{ist}$  denotes TFP of firm  $i$  in sector  $s$  in year  $t$ ,  $Y_{ist}$  is real value added,  $L_{ist}$  is the number of employees,  $K_{ist}$  is the firm's value of real fixed assets, and  $\alpha_s$  denotes labor share in sector  $s$ . Thus, the assumption of constant returns to scale in every sector is made.

Second, a production function of the following form is estimated using OLS for each NACE sector:

$$\ln Y_{ist} = \beta_s + \alpha_s^L \ln L_{ist} + \alpha_s^K \ln K_{ist} + \gamma_t + \varepsilon_{ist}$$

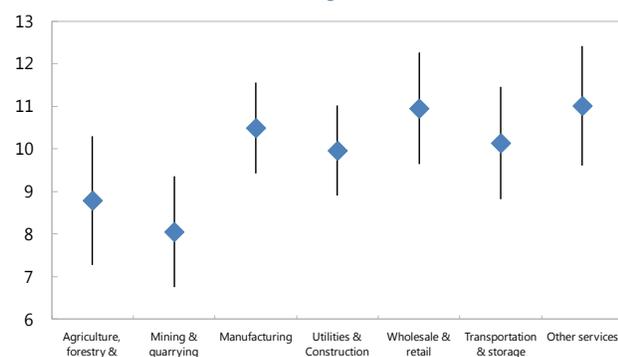
Year fixed effects are included to capture time-varying common shocks to all sectors. We obtain the labor and capital shares from the regressions no longer assuming constant returns to scale, and use them to compute firm TFP as before.

Third, we estimate the same production function but using the Levinsohn-Petrin (LP) methodology of instrumenting for the unobserved productivity shock (Levinsohn and Petrin, 2003). The idea is that more productive firms tend to hire more inputs, thus rendering input uses correlated with productivity and causing the OLS coefficients to be inconsistent and biased. In line with the literature, we use as instrument the firm's working capital (defined as the difference between current assets and current liabilities), in the absence of good data on intermediate inputs.

The three measures of firm TFP are highly and significantly correlated with each other. The simple correlations range from 0.54 to 0.8. Average firm TFP (using the LP method) is relatively higher in manufacturing and services sectors, whereas it is lower and with more variation across firms in agriculture, forestry and fishing, as well as mining and quarrying.

#### Distribution of TFP in Selected Sectors, 2014

(Mean and 2-standard deviation band, in logs)



Sources: Orbis and Fund staff calculations.

Note: TFP calculated using Levinsohn-Petrin method.

## D. Results and Policy Experiments

**19. Our analysis indicates that product market regulation lowers productivity in the directly regulated industries.**<sup>19</sup> The analysis suggests that firms operating in sectors that are more heavily regulated tend to experience lower productivity levels, measured by either labor productivity

<sup>19</sup> The reported results for direct and indirect regulatory burdens use the Levinsohn-Petrin measure of TFP (our preferred measure) and an aggregate indicator of PMR (covering both the network and retail sectors) and upstream PMR for all sectors. For results using other TFP measures and when considering separately the effect of PMR in network and retail and sectors, see Appendix III.

or TFP (Table 1).<sup>20</sup> However, while the results are statistically significant for small firms and medium-sized firms, there is no firm evidence that micro and large firms are affected. The adverse impact from the direct regulatory burden is economically significant: for example, a one-standard-deviation reduction in the *PMR* indicator correlates with higher average level of TFP by 10 percent for small firms and 7 percent for medium firms.

**Table 1. Denmark: Direct Effect of PMR on Firm Productivity**

Variables	Labor productivity				TFP			
	Micro	Small	Medium	Large	Micro	Small	Medium	Large
<i>PMR</i>	-0.232 [0.251]	-0.538 [0.313]*	-0.256 [0.163]	0.018 [0.270]	-0.377 [0.248]	-0.512 [0.285]*	-0.382 [0.182]**	-0.112 [0.226]
Observations	5,345	2,498	1,020	326	5,193	2,493	1,020	326
R-squared	0.385	0.538	0.584	0.599	0.317	0.559	0.695	0.769

Robust standard errors in brackets. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1.  
Source: Fund staff calculations.

**20. More importantly, we find robust evidence that PMR in network and retail sectors indirectly affects firm productivity in other sectors.** The results for the indirect regulatory burden are robust to multiple specifications and productivity measures, and they point to a negative and significant correlation between *upstream PMR* and firm productivity in all sectors (Table 2). Firms operating in sectors that rely more heavily on inputs from the regulated industries are likely to be less productive than others. Our results also suggest that the impact of PMR on firm productivity varies by firm size, similar to the findings in the literature, probably due to variation in sensitivity to input costs among firm size classes. The productivity reducing effect of regulation is most pronounced for micro and small firms, whereas there is no evidence that large firms are affected. A one-standard-deviation reduction in *PMR* implies 6 percent higher TFP for micro and small firms but only 3.5 percent higher for medium-sized firms.<sup>21</sup> The results are on the same order of magnitude as those estimated for Italy (Lanau and Topalova, 2016). The magnitude of the coefficients is similar for labor productivity and TFP, but the explanatory power of the regressions is higher for TFP.

**Table 2. Denmark: Indirect Effect of PMR on Firm Productivity**

Variables	Labor productivity				TFP			
	Micro	Small	Medium	Large	Micro	Small	Medium	Large
<i>Upstream PMR</i>	-0.152 [0.021]***	-0.167 [0.023]***	-0.099 [0.022]***	0.011 [0.038]	-0.182 [0.023]***	-0.175 [0.024]***	-0.104 [0.023]***	0.004 [0.035]
Observations	37,521	21,097	9,403	1,921	36,057	20,984	9,391	1,921
R-squared	0.192	0.380	0.432	0.509	0.478	0.748	0.824	0.844

Robust standard errors in brackets. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1.  
Source: Fund staff calculations.

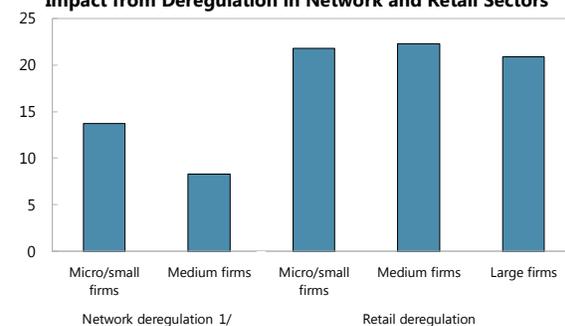
<sup>20</sup> All regressions control for firm age, firm leverage, and the output gap. They also include region fixed effects as well as sector fixed effects, and robust standard errors are clustered at the sector-year level. The estimation sample for the direct PMR effect contains only of firms operating in the seven network industries and in retail trade, whereas the sample for indirect upstream PMR contains firms in all sectors of the economy.

<sup>21</sup> To calculate the average effect on firm productivity across all sectors from reducing *Upstream PMR*, we keep input use intensity across all sectors constant at the average level.

**21. Regulation in retail industries impacts downstream sectors more than that in network sectors.** We repeat the analysis of indirect regulatory burdens, separating the *upstream PMR* indicators for network and retail sectors (Appendix III). Whereas the coefficients on *upstream PMR* are negative and highly significant for both types of regulation, they are larger for retail regulation, implying that productivity gains from relaxing regulation in the retail industry are likely higher than those from relaxing network regulation. Further, network *upstream PMR* has the largest impact on micro and small firms (Appendix III, Table A3.1). The estimated impact of retail *upstream PMR* is more evenly distributed across firm sizes though the coefficients remain slightly larger for small to medium size firms (Appendix III, Table A3.2).

**22. Closing half of the PMR gap with the European OECD frontier would generate sizable productivity gains.** In a simple policy experiment, we use the estimated coefficients from Tables 5 and 6 to calculate the average change in steady-state firm TFP from reducing Denmark's *upstream PMR* indicator for network or retail sectors such that half of the distance between Denmark and the frontier is closed. Our calculations suggest that, for example, closing half of the gap in network regulation would increase the average level of firm TFP in Denmark by roughly 12 percent, with the largest benefits accruing to smaller downstream firms. The productivity gains from reducing regulation in the retail sector are even larger, at about 20 percent of TFP on average. In contrast to network deregulation, relaxing regulation in retail services would also benefit large firms.

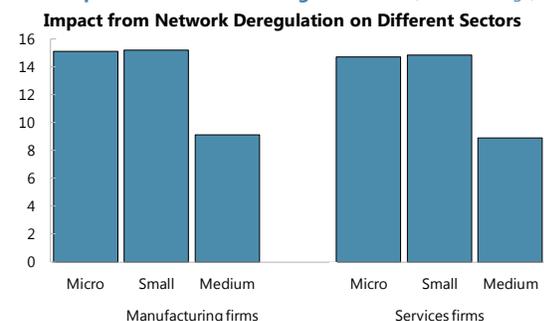
**Relaxing Half of the Regulatory Gap between Denmark and the European Frontier on Average Firm TFP (Percent change)**  
Impact from Deregulation in Network and Retail Sectors



Sources: Fund staff estimates. 1/ Results not significant for large firms.

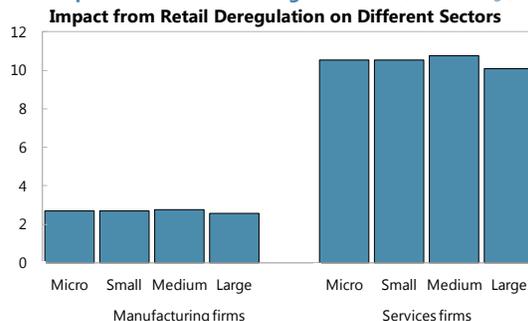
**23. The productivity boost from deregulation varies across different downstream industries, depending on how intensively they use inputs from the regulated industries.** We examine whether productivity gains from product market deregulation differ for firms in different sectors. For example, manufacturing firms would benefit slightly more from network deregulation than firms in services, possibly as manufacturers tend to employ more network inputs for the production (e.g., use of electricity and gas) and distribution (e.g., through rail and road infrastructure) of their products. On the other hand, firms in the services sector would benefit substantially more from retail deregulation, possibly reflecting the large productivity gap in the services sector, but also the intensive use of retail input among services firms given the customer-oriented nature of services.

**Relaxing Half of the Regulatory Gap between Denmark and the European Frontier on Average Firm TFP (Percent change)**



Source: Fund staff estimates. Note: Results not significant for large firms.

**Relaxing Half of the Regulatory Gap between Denmark and the European Frontier on Average Firm TFP (Percent change)**



Source: Fund staff estimates.

**24. These results should be interpreted with the usual caveats.** Our estimates of productivity gains from further deregulation of product markets for Denmark are broadly in line with estimates in the literature (e.g., Copenhagen Economics, 2013b for Denmark, Lanau and Topalova, 2016 for Italy). Nevertheless, the results should be interpreted with care—notably in view of the crude nature of the OECD PMR indicators—and can only be indicative of potential productivity gains. As is well known, it is an empirical challenge to isolate the impact of any structural reform from that of other reforms that may be implemented at or around the same time. In addition, some degree of regulation in certain sectors may be justified by other policy considerations or societal preferences. The paper does not pass judgment on whether lower scores on the individual PMR indicators are necessarily optimal from other than strictly economic criteria.

## E. Conclusion

**25. There is scope for significantly improving productivity in Denmark from reforming the product markets.** Sizable regulation remains in some network sectors and retail industries, which hinders competition and firm performance. Moreover, the impact pertains not just to the regulated industry *per se* but also to downstream sectors that use network and retail inputs. Our analysis suggests that product market deregulation in network and retail sectors could significantly raise labor productivity and TFP for Danish firms.

## Appendix I. Data Sample

**We retrieve data on all firms in Denmark for which value added and the number of employees are available.** Our data comes from the Orbis database provided by Bureau Van Dijk over the period 2005–2014, resulting in a total of 139,063 firm-year observations. Our selection of companies focuses on unconsolidated financial statements where available and consolidated statements otherwise, excluding subsidiaries to avoid double-counting of firms. Most companies are located in Hovedstaden (36 percent), Midtjylland (22 percent), Syddanmark (19 percent), Sjaelland (12 percent), and Nordjylland (7 percent), and the remaining firms are from three smaller regions in Denmark.

**We apply a number of filtering rules to the original sample.** In line with the corporate literature, we drop all firms in the financial services industry because their high leverage is not an indication of distress and they also hold liquidity to meet regulatory requirements and not to undertake positive net present value

investment projects (Fama and French, 1992; Bates and others, 2009).<sup>1</sup> We also delete observations with negative values for key variables—such as current assets, fixed assets, total assets, leverage, shareholder funds, sales, and cost of employees; we drop the bottom and top 5 percent of the distribution of return on assets and return on equity, and keep only data as of 2010 due to

<b>Sector of Economic Activity</b>	<b>Number of firms</b>	<b>Value Added Share</b>	<b>Employment Share</b>
A - Agriculture, forestry and fishing	440	0.6	0.5
B - Mining and quarrying	52	0.7	0.3
C - Manufacturing	3,843	22.8	22.3
D- Electricity, gas, steam and air cond.	121	1.7	0.7
E- Water supply; sewerage, waste managmt	154	0.9	0.8
F - Construction	4,605	4.5	6.7
G- Wholesale and retail trade; repair	8,684	20.5	24.6
H - Transportation and storage	1,388	27.7	21.8
I- Accommodation and food service activ.	996	1.4	2.0
J - Information and communication	2,028	7.0	5.9
L - Real estate activities	51	0.1	0.1
M- Professional, scientific and technical	3,437	6.6	6.9
N- Administrative and support service	1,336	3.6	4.9
P - Education	190	0.1	0.1
Q- Human health and social work activit.	970	0.6	0.9
R - Arts, entertainment and recreation	301	0.4	0.4
S - Other service activities	385	0.5	0.7
<i>Total</i>	<i>28,981</i>	<i>100</i>	<i>100</i>

Source: Fund staff calculations.

scarce firm representation for prior years. Our final sample includes close to 71,374 firm-year observations over 2010–2014 distributed across 29,000 firms in 17 sectors. The majority of firms belongs to wholesale and retail trade, followed by construction, manufacturing, professional services, and information and communication sectors. Transportation and storage sector, however, generates the largest value added share in the economy along with manufacturing and wholesale and retail trade, with these sectors also employing the largest share of employees.

<sup>1</sup> We also exclude companies in public administration and defense.

**The majority of firms in Denmark are very small privately-held firms.** We group firms in different size categories using the number of employees. Micro firm employ less than 10 employees (62 percent of the sample), firms with employees less than 50 but more than 10 are labeled as small (27 percent of total), medium firm have between 50 and 250 employees (9 percent of total), and above that are large firms (2 percent). The overwhelming majority of firms (99.8 percent) are privately-held and a mere 0.2 percent is listed. These figures suggest that focusing on large or listed firms only is likely to provide an incomplete picture of economic activity in Denmark. Also, 90 percent of firms are active, and the rest is ether dissolved, merged, or bankrupt. We keep both active and inactive firms in our sample to capture the dynamics of the market in terms of not just entry but also exit.

**Firms across different size classes have different asset composition and more similar funding structure.** In Denmark, very small firms invest much less in fixed assets than medium and large firms, which could be due to the type of sector that they operate in and which requires more investment in working

capital than in tangible assets. Noteworthy is that the capital structure of firms across different size classes does not exhibit large variations, suggesting that access to financing for the smallest firms may not be an impediment. Also,

Firm Size	Current Assets / Fixed Assets / Total Debt / Total Equity / Return on Assets		Return on Equity			
	Total Assets	Total Assets	Total Assets	Total Assets	Assets	Equity
Micro	78.5	21.5	63.0	37.0	5.0	16.3
Obs.	19,127	19,127	19,127	19,127	19,127	19,127
Small	76.5	23.5	67.1	32.9	5.6	19.2
Obs.	7,272	7,272	7,272	7,272	7,272	7,272
Medium	68.2	31.8	65.3	34.7	5.4	15.6
Obs.	2,166	2,166	2,166	2,166	2,166	2,166
Large	57.0	43.0	63.2	36.8	5.1	14.7
Obs.	414	414	414	414	414	414
All	76.9	23.1	64.4	35.6	5.3	16.9
	28,979	28,979	28,979	28,979	28,979	28,979

Source: Fund staff calculations.

standard profitability indicators do not exhibit great variability across firms of different size, albeit higher return on assets and return on equity for small firms. Finally, 8 percent of firms in our sample are start-ups (established less than 5 years ago), 49 percent are young (between 5 and 10 years of operations), 37 percent are mature (between 10 and 35 years of age), and the remaining 7 percent have been in the market for more than 35 years.

## Appendix II. Variables Definition and Sources

Description and sources of all variables entering the regressions appear in Table A2.1.

<b>Variable</b>	<b>Description</b>	<b>Source</b>
<i>Labor Productivity</i>	Real value added per employee	Orbis and authors' calculations
<i>TFP - Solow residual</i>	Solow residual (Box 3)	Orbis and authors' calculations
<i>TFP - OLS</i>	OLS residual (Box 3)	Orbis and authors' calculations
<i>TFP - Levinsohn-Petrin</i>	Levinsohn-Petrin residual (Box 3)	Orbis and authors' calculations
<i>Product Market Reform (PMR)</i>	PMR: Network & Retail	OECD and authors' calculations
<i>Network PMR</i>	PMR: 7 Network industries	OECD
<i>Retail PMR</i>	PMR: Retail trade	OECD
<i>Downstream PMR</i>	Cross-product of PMR and input intensity	OECD, Statistics Denmark, and authors' calculations
<i>Downstream PMR - Network</i>	Downstream PMR: 7 Network industries	OECD, Statistics Denmark, and authors' calculations
<i>Downstream PMR - Retail</i>	Downstream PMR: Retail trade	OECD, Statistics Denmark, and authors' calculations
<i>Firm Leverage</i>	Debt to total assets	Orbis and authors' calculations
<i>Output Gap</i>	GDP	WEO database

Source: Fund Staff calculations.

Summary statistics on the key variables entering the empirical specification appear in Table A2.2. Since we keep both active and inactive or dissolved firms, the latter typically may have negative equity and hence the debt-to-assets ratio that exceeds 100 percent.

<b>Variable</b>	<b>Obs</b>	<b>Mean</b>	<b>Std. Dev.</b>	<b>Min</b>	<b>Max</b>
<i>Labor Productivity</i>	69,952	10.8	0.7	3.6	17.8
<i>TFP - Solow residual</i>	68,363	8.2	1.4	-3.8	13.2
<i>TFP - OLS</i>	68,363	9.9	0.7	2.8	16.9
<i>TFP - Levinsohn-Petrin</i>	68,363	10.6	0.9	1.1	17.4
<i>PMR</i>	9,294	1.6	0.2	0.4	2.6
<i>PMR - Network</i>	2,605	1.4	0.4	0.4	2.6
<i>PMR - Retail</i>	6,689	1.7	0.0	1.7	1.8
<i>Downstream PMR</i>	71,364	6.7	4.2	0.1	21.8
<i>Network</i>	71,365	5.6	4.5	0.1	21.2
<i>Downstream PMR - Retail</i>	71,364	1.1	2.0	0.0	7.2
<i>Firm Leverage</i>	71,374	61.2	26.7	0.0	156.2
<i>Output Gap</i>	71,374	-1.4	0.4	-1.9	-0.7

<sup>1</sup> *Labor Productivity* and *TFP* variables are in logs; *PMR* variables are indices (0-6); *Downstream PMR*, *Firm Leverage*, and *Output Gap* variables are in percent.

Source: Fund staff calculations.

## Appendix III. Additional Results

The results for the direct and indirect effect of PMR on firm productivity in the baseline are robust to alternative specifications.

**First, we replace the *upstream PMR* for all regulated sectors with either the *upstream PMR* for network or retail sectors** (Tables 5 and 6). Similar to the results using all regulated sectors' *PMR*, there is a negative and significant correlation between *upstream PMR* in either network or retail sectors and the productivity of micro, small, and medium firms across all sectors. Unlike the results based on aggregated *upstream PMR*, retail *PMR* also has significant indirect effects on large firms' productivity in the economy. Moreover, the robustness check reveals the differentiated magnitude of the positive downstream effects from the liberalization of network sectors and retail trade. The average indirect impacts of retail trade *PMR* on firm productivity are three times larger than that of all regulated sectors' *PMR*, whereas that of the network sector *PMR* is slightly lower.

**Table A3.1. Indirect Effect of Network PMR on Firm Productivity**

Variables	Labor productivity				TFP			
	Micro	Small	Medium	Large	Micro	Small	Medium	Large
<i>Upstream PMR-Network</i>	-0.136 [0.022]***	-0.157 [0.024]***	-0.091 [0.023]***	0.024 [0.039]	-0.154 [0.023]***	-0.155 [0.024]***	-0.093 [0.023]***	0.021 [0.037]
Observations	37,521	21,098	9,403	1,921	36,057	20,985	9,391	1,921
R-squared	0.191	0.381	0.431	0.509	0.477	0.748	0.824	0.844

Robust standard errors in brackets. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1.  
Source: Fund staff calculations.

**Table A3.2. Indirect Effect of Retail PMR on Firm Productivity**

Variables	Labor productivity				TFP			
	Micro	Small	Medium	Large	Micro	Small	Medium	Large
<i>Upstream PMR-Retail</i>	-0.516 [0.069]***	-0.529 [0.074]***	-0.582 [0.102]***	-0.505 [0.182]***	-0.721 [0.074]***	-0.720 [0.070]***	-0.737 [0.096]***	-0.690 [0.181]***
Observations	37,521	21,097	9,403	1,921	36,057	20,984	9,391	1,921
R-squared	0.191	0.379	0.431	0.510	0.478	0.748	0.824	0.844

Robust standard errors in brackets. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1.  
Source: Fund staff calculations.

**Second, the results for both the direct and indirect regulatory burdens are robust to using alternative productivity measures.** In addition to the results for labor productivity and the Levinsohn-Petrin measure of TFP reported in Box 3, we test the sensitivity of our results to using two alternative TFP measures (described in Box 2). The baseline results for both direct and indirect impact of PMR hold in both robustness checks.

**Table A3.3. Direct Effect of PMR on Firm TFP**

Variables	TFP - Solow residual				TFP - OLS			
	Micro	Small	Medium	Large	Micro	Small	Medium	Large
<i>PMR</i>	-1.091 [0.321]***	-0.769 [0.419]*	-1.909 [0.503]***	-1.579 [0.417]***	-0.292 [0.242]	-0.371 [0.302]	-0.436 [0.213]**	-0.024 [0.237]
Observations	5,193	2,493	1,020	326	5,193	2,493	1,020	326
R-squared	0.763	0.873	0.882	0.920	0.341	0.491	0.512	0.607

Robust standard errors in brackets. \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ .

Source: Fund staff calculations.

**Table A3.4. Indirect Effect of PMR on Firm TFP**

Variables	TFP - Solow residual				TFP - OLS			
	Micro	Small	Medium	Large	Micro	Small	Medium	Large
<i>Upstream PMR</i>	-0.201 [0.046]***	-0.198 [0.046]***	-0.212 [0.049]***	-0.101 [0.063]	-0.171 [0.022]***	-0.160 [0.023]***	-0.105 [0.022]***	0.009 [0.034]
Observations	36,057	20,984	9,391	1,921	36,057	20,984	9,391	1,921
R-squared	0.746	0.822	0.861	0.889	0.326	0.551	0.609	0.609

Robust standard errors in brackets. \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ .

Source: Fund staff calculations.

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