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A Dynamic Analysis of Entry Regulations and Productivity in Retail Trade*

Florin Maican[†] and Matilda Orth[‡]

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Abstract

Quantifying possible inefficiencies stemming from regulation is important to both policymakers and researchers. We use a dynamic structural model to evaluate the role of local market entry regulations in the productivity of retail trade. Our model is flexible with respect to how local market regulations influence store productivity and controls for demand in local markets. We combine the structural approach with detailed data on all stores in the Swedish retail industry. The results show that more liberal entry regulations increase future productivity and that the increase in productivity is larger for small stores and small markets than for large stores and large markets.

Keywords: Retail trade, regulation, imperfect competition, dynamic structural model.

JEL Classification: L11, L81, L88, O30.

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1 Introduction

The impact of regulations on market outcomes is frequently debated in many countries because policy interventions designed to prevent market failure may also lead to inefficiencies. Firm reactions to changes in the market environment depend on firms' productivity levels, which are determined by both internal factors that firms can control and firms' external environment. Yet, little work has attempted to quantify the effect of regulations on productivity (Syverson, 2011). If regulations restrict productivity, both policymakers and researchers must quantify these costs to evaluate the associated changes in welfare and to determine the optimal level of regulation. In this paper, we propose a dynamic structural model to assess the implications of local market entry regulations for the productivity of retail trade.

Isolating and quantifying the effects of entry regulations on productivity requires both careful modeling and comprehensive data. First, entry regulations affect productivity, which must be considered in the estimation of the service production function. Second, retail stores face different incentives to change their productivity in response to regulations depending on their current productivity levels and local market conditions, which in turn affect their future productivity relative to competitors. Any welfare analysis of regulations must consider the full distribution of store responses in local markets. Third, the impact of regulation on productivity must be disentangled from demand shocks, such as increases in market size or structural changes in shopping behavior, to ensure that such shocks are not interpreted as changes in productivity. Fourth, standard problems such as the simultaneity of input choices and selection in the estimation of the service production function and potential endogeneity concerns regarding the stringency of regulations must be considered.

To address these modeling challenges and to accurately measure the effect of regulatory stringency on productivity, we propose a dynamic structural model that

builds on the growing body of literature on heterogeneity in productivity within industries (Ericson and Pakes, 1995; Olley and Pakes, 1996).¹ The model employs a controlled productivity process with respect to local market regulation, allows stores to react differently to changes in regulation, and controls for demand in local markets. Importantly, addressing these modeling challenges would be difficult by simply regressing labor productivity (measured as the value-added per full-time adjusted employee) or a measure of multi-factor productivity on a regulation measure. We combine the structural model with rich panel data for all retail stores in Sweden for the 1996-2002 period and perform separate analyses for eleven subsectors.

Our approach is particularly advantageous because we obtain the full distribution of productivity responses for all stores and calculate the change in aggregate weighted productivity from more liberal entry regulation in local markets. This quantification exercise attempts to elucidate an issue of direct policy interest. Further, this framework provides a point of departure for a more complete welfare analysis of local market entry regulations and can be applied to other imperfectly competitive, regulated industries. Because stores cannot influence or form expectations about the future stringency of regulation, we follow a two-step estimation procedure to alleviate endogeneity concerns regarding regulation. Our model captures the net effect of regulation on productivity and provides a clear identification strategy for heterogeneous store responses to regulatory changes, which does not require the assumptions that are necessary in a dynamic game framework.²

Various features make the retail industry appropriate for examining the impact of regulation on productivity. First, retail markets are subject to substantial regulation that is more restrictive in Europe than in the U.S. Specifically, in Europe, entry

¹Recent contributions on manufacturing and/or trade include Levinsohn and Petrin (2003); Akerberg et al. (2006); Akerberg et al. (2007); De Loecker (2011); Doraszelski and Jaumandreu (2013); and Gandhi et al. (2013).

²Such assumptions raise concerns about, for instance, functional forms of cost functions, multiple equilibria, and aggregation to reduce the computational complexity (Pakes et al., 2007; Dunne et al., 2013; Maican and Orth, 2013).

regulation empowers local authorities to govern the entry of new stores. Second, retail trade is thought to substantially contribute to the frequently debated productivity gap between Europe and the U.S. (Gordon, 2004; Schivardi and Viviano, 2011). Examples of productivity improvements in retail trade include the adoption of information technology (e.g., scanners, barcodes, and credit card processing machines), inventory and price management, wholesale and distribution networks, economies of scale and density, intangible assets and skills (e.g., brand recognition, reputation, and human capital), and vertical contracts and integration (Holmes, 2001; Schivardi and Viviano, 2011; Basker, 2012). Third, retail has become increasingly important for overall economic activity in modern economies, currently accounting for up to 6 percent of GDP and 10 percent of employment. Retail markets in both Europe and the U.S. have trended toward fewer, larger stores. Further, in U.S. retail trade, entry and exit explain nearly all labor productivity growth. By contrast, in the manufacturing sector, entry and exit account for approximately 30 percent of total growth (Schmitz, 2005; Foster et al., 2006).

In Sweden, all stores are subject to regulation, providing its 290 municipalities power to make land use decisions. Each potential entrant must submit a formal application to the local government. The decision to change a geographic zoning restriction and thus to allow a store to enter the market requires a consideration of the market structure, price, traffic, and environmental consequences. Such regulation decisions are binding, and local authorities rarely approve all applications.

To measure the stringency of regulation, we draw on previous work on land use and entry regulations and employ rich data that vary across local markets and over time to control for market size and the potential endogeneity of regulation. We consider the number of approved applications divided by the population density, the number of approved applications relative to the number of stores, and the number of approved applications relative to the number of zoning plans (Bertrand and Kramarz, 2002; Schivardi and Viviano, 2011; Sadun, 2014). For robustness,

we also include index variables with different weights and the number of approved applications (Suzuki, 2013; Turner et al., 2014).

The results show that productivity is higher under more liberal entry regulations and substantial heterogeneity exists in the marginal effects across stores and local markets. Specifically, store productivity increases by 1.8 percent on average per additional approved application across all subsectors. In local markets, the median increase in aggregate productivity from an additional approval is 2-5 percent in four subsectors (textile, footwear, books, and toys) and 0.2-1 percent in the remaining seven subsectors. Moreover, store productivity increases by an additional 1 percentage point for small stores compared with large stores, and aggregate local market productivity increases by an additional 1-2 percentage points in small markets compared with large markets. These results are robust to the use of various semiparametric estimators, the use of different measures of regulation, and the inclusion of controls for the potential endogeneity of regulation. In addition, we find increasing returns to scale in most subsectors of Swedish retail and that it is important to allow for a controlled productivity process, to allow for flexibility in how stores react to regulation, and to control for local market demand and omitted prices. Our findings highlight the non-trivial importance of entry regulation in the productivity of local retail markets.

This paper makes several contributions to the literature. Surprisingly few studies have aimed to examine the importance of regulation for productivity, which is currently a key issue within the productivity literature (Syverson, 2011). To the best of our knowledge, this paper is among the first to utilize a dynamic structural model to quantify the effects of entry regulation on productivity in retail. In doing so, this paper contributes a structural framework to previous research on how regulations affect productivity (Djankov et al., 2002; Syverson, 2011; Greenstone et al., 2012; Buccirosi et al., 2013) and relates to a growing body of literature on land use regulation (Maican and Orth, 2013; Suzuki, 2013; Turner et al., 2014). Further, the

proposed framework complements the existing retail literature (Bertrand and Kramarz, 2002; Haskel and Sadun, 2011; Schivardi and Viviano, 2011; Sadun, 2014)³ and contributes to recent work on productivity dynamics in retail (Foster et al., 2006; Basker, 2007; Basker, 2012). This study’s strengths include the structural framework and rich data on all stores across retail industries, which allows for a careful investigation of both dynamics and heterogeneity in store-level responses to changes in entry regulation. The isolation of demand effects from productivity in a local market for services has recently been attempted in a companion paper on retail food (Maican and Orth, 2009), as well as in previous research at the industry level in the manufacturing sector (Klette and Griliches, 1996; Levinsohn and Melitz, 2006; Katayama et al., 2009; De Loecker, 2011; Pozzi and Schivardi, 2012; Doraszelski and Jaumandreu, 2013).⁴ Because of the difficulty of measuring physical output and defining retail prices, both technical and quality-adjusted productivity measures (i.e., true productivity without demand shocks and the sum of technical productivity and remaining demand shocks) should be considered. The proposed framework is general and can be applied to retail and services industries in other countries.

The remainder of the paper proceeds as follows: Section 2 discusses entry regulation and the utilized data. Section 3 provides reduced-form empirical evidence of the effect of entry regulation on productivity. Section 4 describes the modeling approach. Section 5 discusses productivity and the results of the structural model

³Schivardi and Viviano (2011) find that strict entry regulations hinder productivity in the Italian retail trade. Sadun (2014) finds that an increase in approved applications results in higher employment growth, whereas Haskel and Sadun (2011) find that total factor productivity in retail decreased after the 1996 planning regulation in the U.K. In France, entry regulation is found to slow labor growth (Bertrand and Kramarz, 2002).

⁴Recent research has linked establishment and product-level data on prices and quantities in samples of narrowly defined manufacturing firms (e.g., Petrin and Warzynski, 2012). Relying on only a small sample of retail stores, however, severely limits the evaluation of regulations in local markets. To the best of our knowledge, no study of productivity in retail combines detailed store-level information and store-level prices for a total population of stores. Griffith and Harmgart (2005), Reynolds et al. (2005), and Maican and Orth (2009) outline the characteristics of retail markets.

of the impact of regulation on productivity. Section 6 concludes. In several places, we refer to an online appendix that contains various analyses that are not discussed in the paper.

2 Entry regulation and data

The majority of OECD countries have entry regulations that empower local authorities to make decisions regarding the entry of new stores. Such regulations aim to prevent possible negative externalities regarding, for instance, competition, lack of access for consumers, and environmental aspects. Entry restrictions differ substantially across countries, however. Whereas some countries strictly regulate large entrants, more flexible zoning laws exist, for instance, in the U.S. (Hoj et al., 1995; Pilat, 1997; Boylaud and Nicoletti, 2001; Nicoletti and Scarpetta, 2003; Griffith and Harmgart, 2005; Pilat, 2005).

In Sweden, the Plan and Building Act (“Plan och Bygglagen” or, PBL) empowers the 290 municipalities to process applications for new entrants. Geographical zoning allows municipalities to manage land use, i.e., all stores are subject to this regulation.⁵ Thus, if a store wants to enter a specific local market, it must submit a formal application to the municipality. In processing new entrant applications, local governments must evaluate the market structure, store supply, product assortment, price, and environmental consequences. PBL decisions are binding, and local authorities rarely approve all applications. Inter-municipality issues regarding entry are addressed by the 21 county administrative boards. The PBL is considered a major barrier to entry, resulting in diverse outcomes, such as different price levels across local markets (Swedish Competition Authority, 2001:4). Several reports stress the need for improved analysis of how regulations affect market outcomes (Pi-

⁵Although hours of operation are also regulated in some countries, they are not regulated in Sweden.

lat, 1997; Swedish Competition Authority, 2001:4; Swedish Competition Authority, 2004:2). Online Appendix A describes the PBL in greater detail.

Measures of regulation. To measure regulatory stringency in local markets, we collect data from a variety of sources. A limitation of existing research on land use and entry regulations is the absence of an ideal measure of regulation.⁶ Consistent with previous research, we include a number of measures that vary across markets and over time to control for market size and the potential endogeneity of regulation.

The first data set contains the number applications approved by local authorities. We access the number of approved PBL applications that allow the entry of retail stores. The data were collected from surveys of 163 of 290 municipalities for the 1987-1992, 1992-1996, and 1997-2000 periods (Swedish Competition Authority, 2001:4). We also access the total number of PBL approvals for each municipality and year (Swedish Mapping, Cadastral and Land Registration Authority (Lantmäteriet)). The total number of PBL approvals differs from the PBL approvals that allow the entry of retail stores because the total number of PBL approvals includes PBL approvals related to all types of commercial activities (not only retail) and residential purposes.⁷ Both measures of the number of PBL approvals are flow variables, i.e., they capture the number of new applications that are approved. The correlation between these two measures is 0.83. Because of the high correlation, we utilize the data for all approvals (rather than only approvals of new retail stores) to allow for the use all local markets and years.

The second data set contains the total number of zoning plans for each municipality and year (Swedish Mapping, Cadastral and Land Registration Authority (Lantmäteriet)). Each local market is divided into a number of well-defined geographic areas called zoning plans that are subject to entry regulation. The existing

⁶Bertrand and Kramarz (2002); Gyourko et al. (2008); Schivardi and Viviano (2011); Suzuki (2013); Sadun (2014) and Turner et al. (2014).

⁷Suzuki (2013) utilizes data on applications for residential purposes to evaluate cost changes in the lodging industry. Our data differ in that we include applications for both commercial and residential purposes, which more closely approximates actual regulation enforcement.

number of zoning plans is a stock variable, i.e., it captures the number of geographic areas for each market-year observation. An approved PBL application can change the number of zoning plans for the following year.

The third data set includes information on the share of seats for each political party in local municipal governments, as the implementation of the PBL depends on the preferences of politicians in local governments (Bertrand and Kramarz, 2002; Schivardi and Viviano, 2011). In particular, non-socialist local governments are expected to apply the PBL more liberally.⁸ The exogeneity of political preferences assumes that land use issues are not decisive in local elections. Indeed, Swedish municipalities have many responsibilities, and spending regarding childcare, education and elder care are more likely to influence voter decisions than entry regulation.

To produce a sound measure of regulation, we must ensure that the number of PBL approvals is comparable across local markets and must control for larger municipalities, which might have a higher number of approvals only because of their size. We construct the following entry regulation measures for each municipality and year: (i) the number of PBL approvals divided by the population density; (ii) the number of PBL approvals divided by the number of stores; (iii) the number of PBL approvals divided by the total number of zoning plans for each municipality and year. In addition, for robustness, we consider (iv) index variables that combine our various data sources⁹ and (v) the number of approvals. The alternative market size measures allow us to evaluate the robustness of our normalization and acknowledge that the number of approvals is proportional to each market size vari-

⁸This pattern is contrary to, for instance, France and Italy. It is well established that the Swedish non-socialist government favors liberalization. For example, the non-socialist government has deregulated the pharmacy and telecom markets.

⁹This index draws on previous research on regulation conducted by Suzuki (2013). The index variable includes the share of non-socialist seats in the local government, the number of approvals divided by the number of stores, and the number of approvals divided by the number of zoning plans. The main index variable specification applies half of the weight to the share of non-socialist seats and one-quarter each to both measures of the shares of PBL approvals. Higher regulation index values indicate more liberal regulatory environments. Online Appendix F.2 provides further details on this regulation index variable.

able. The advantage of the regulation measure based on the ratio of PBL approvals to population density is that it captures both market size and geographic density, which are important in retail. Although we present the results of several entry regulation measures, our preferred measure for the main specification is the number of approvals divided by the population density.

If local authorities were to approve all PBL applications, then the number of approvals would measure competition rather than regulation. Although we do not consider the number of rejections, local authorities rarely approve all applications (i.e., there are small local markets), and because the decisions are binding, our measure can capture regulatory stringency. The rate of approval (which requires observations of the number of both approvals and rejections) might be an optimal regulation measure, but this measure is limited in that decisions to apply in a market are a function of the expected success rate.

Local markets. Our modeling approach considers local competition, and market size is determined by subsector, store size, and distance to competitors. We expect the size of local markets to decrease as the durability of goods increases. The 21 counties are most likely too large to reflect local markets, whereas the more than 1,600 localities are most likely too small. However, the 290 municipalities that make entry decisions are a reasonable local market size for the majority of Swedish retail products. Therefore, we define the 290 Swedish municipalities as local markets.

Store and local market data. We use detailed data from Statistics Sweden (SCB) that include all retail stores for the period 1996 to 2002. The unit of observation is the store, which is identified by its tax reporting number. The data include (i) Financial Statistics (FS), which contain input and output measures such as sales, value-added, and investments, and, (ii) Regional Labor Market Statistics (RAMS), which contain number of employees and wages. Most stores consist of one

unit, but some stores can consist of several units because of, e.g., joint ownership.¹⁰ If the data include more than one store, we observe total rather than average inputs and outputs. We use all stores that belong to SNI-code 52, “Retail trade, except of motor vehicles and motorcycles; repair of personal household goods.” Because we have access to detailed information, we can use five-digit industry codes (a total of 74 for retail). To simplify the presentation and to jointly analyze similar product groups, we consider the following eleven subsectors (discussed in detail in online Appendix B) in the empirical analysis: textiles, clothing, footwear, furniture, electronics, hardware, books, sports, watches, toys, and computers.

SCB provides direct value-added measures. We deflate sales, value-added, investments and capital by sub-groups of the Consumer Price Index (CPI), and we control for subsector prices because subsectors are heterogeneous. Separate sub-groups are used for textiles, clothing, footwear, furniture, hardware, books and computers, and for the remaining subsectors, we use the CPI. Finally, we include municipality characteristics, such as population, population density, and income.

Summary statistics. Table 1 presents various summary statistics for the Swedish retail sector during the 1996-2002 period. Total sales increased by 34 percent to 326 billion SEK in 2002. The value-added is 59 billion SEK in 2002, implying an increase of 27 percent since 1996. Over the full period, investment increased by 47 percent to 5 billion SEK. The number of employees (full-time adjusted yearly average) increased from 144,000 to 159,000, i.e., a 10 percent increase. The opposite trend is observed for the number of stores, which decreased by 10 percent during this period. These industry-level statistics indicate pronounced restructuring in the retail industry towards fewer, larger stores. The largest subsector is clothing, followed by furniture and hardware.

Table 2 presents entry and exit rates in local markets by subsector and store

¹⁰Anonymity prevents us from identifying owners and connecting individual units with stores (see online Appendix B for a detailed description of the data). Joint reporting of several stores is likely to occur at headquarters.

size. For example, in the toys subsector, exit rates are high, and large entrants are common. The entry of small stores is most common in clothing, furniture, hardware, and sports. Hardware and sports are the only subsectors that exhibit net entry, whereas all other subsectors exhibit net exit. The highest outflow of stores is observed in textiles, books, and footwear.

The median local market approves 10 PBL applications per year (Table 3). The median number of approvals by number of stores is 0.076, whereas the median number of approvals by the population density is 0.123. All the entry regulation measures show considerable variation across local markets and over time. The approvals divided by the number of stores and the approvals divided by the number of zoning plans is approximately twice as large in the 75th percentile market as in the 25th percentile market. The corresponding difference is up to five times larger for the number of approvals by the population density.

Table 4 shows that the entry regulation measures are positively correlated, with correlations varying between 0.22 and 0.52.¹¹ Further, markets with more liberal regulation, as measured by the number of approvals divided by the population density, have more stores per capita (0.27) and lower Herfindahl index [HHI] values (-0.10) than other markets.¹² Table 5 displays the regression results for the local competition measures, the HHI and the entry rate, with each of the regulation measure, local market controls, and year and subsector fixed effects included as explanatory variables. The results indicate that more liberal regulation decreases the HHI and increases entry rates. These results provide evidence of a positive and

¹¹Municipalities with a non-socialist majorities approved more applications. The correlation between the share of non-socialist seats and the number of approved applications is 0.45. The corresponding correlation is 0.25 for the number of approvals divided by the number of zoning plans, and the correlations for the regulation index variables range between 0.74 and 0.87.

¹²The HHI, which is constructed by using market shares based on store sales, and entry rates are calculated for each subsector, local market, and year. The number of approvals divided by the number of zoning plans is positively correlated with the entry rate (0.06). The number of approvals divided by the population density is negatively correlated with the entry rate, income, and income growth, likely because rural markets with low population density have lower incomes and entry rates. The other regulation measures are positively correlated with income and income growth.

statistically significant relationship between more liberal regulation and competition in local markets.

3 Reduced-form evidence

To document the empirical relationship between entry regulation and productivity, we present explanatory regressions that include both labor and multi-factor productivity. These reduced-form specifications include three measures of entry regulation: (i) the number of PBL approvals divided by the population density, (ii) the number of PBL approvals divided by the number of stores, and (iii) the number of PBL approvals divided by the number of zoning plans.

3.1 Labor productivity

We define labor productivity as the store value-added per full-time adjusted employee and estimate regressions on the pooled sample of all stores and subsectors. Table 6 displays the results for two specifications for regulation measures (i)-(iii) using OLS estimator with standard errors clustered by local market.¹³ The first specification includes a one-year lagged measure of regulation, income growth, population, population density, and fixed effects for years and subsectors as explanatory variables, whereas the second specification includes dummies for the percentiles of average local market income.

The coefficient for regulation is positive and statistically significant in both specifications, indicating that labor productivity increases with more liberal regulation. The coefficient for income growth is also positive and statistically significant. Most other local market characteristics are significant with expected signs, highlighting

¹³The results are robust to the use of different levels of clustering for the standard errors. Appendix C provides additional results from reduced-form regressions for labor and multi-factor productivity.

the importance of controlling for local demand in estimation of productivity. Overall, the results indicate that store labor productivity is higher in markets with more liberal regulatory environments. This finding is robust to the inclusion of several control variables, such as subsector and year fixed effects, and the use of alternative measures of regulation.

3.2 Multi-factor productivity

In this subsection, we analyze the effect of entry regulation on a measure of multi-factor productivity obtained from a simple service generating function using the OLS estimator, i.e., $\omega_{jt} = y_{jt} - \hat{\beta}_0 - \hat{\beta}_l l_{jt} - \hat{\beta}_k k_{jt}$, where y_{jt} is the log of value-added for store j in year t , l_{jt} is the log of the number of full-time adjusted employees, and k_{jt} is the log of the capital stock.¹⁴ In this case, multi-factor productivity, ω_{jt} , includes both technical productivity and correlated demand shocks. We then regress store multi-factor productivity on a one-year lagged measure of regulation, while controlling for local market covariates and fixed effects for years and subsectors.

Table 6 presents the regression results, which mirror those presented for labor productivity using pooled data. We find a clear, positive relationship between more liberal regulation and multi-factor productivity (productivity and demand). The coefficient for regulation is positive for all regulation measures and is statistically significant for two of three regulation measures (the number of approvals divided by the population density and the number of approvals divided by the number of stores).¹⁵

This simple identification strategy for the impact of regulation on productivity suffers from at least two weaknesses, however. First, it relies on the strong assumption that regulation is uncorrelated with the error term in the service generating function, which includes demand shocks and correlated shocks across local markets

¹⁴Capital stock is defined as $K_{t+1} = (1 - \delta)K_t + I_t$, where δ is the depreciation rate and I_t measures the difference between real gross expenditures on capital and gross retirement of capital.

¹⁵Standard errors are clustered at the local market level.

related to entry regulation. Therefore, we must separate the demand shocks from productivity by modeling both demand and productivity. Second, this identification strategy abstracts from the correlation in store productivity over time and the dynamic effects of regulation on productivity.

Overall, the benchmark results for both labor and multi-factor productivity provide evidence of a positive relationship between more liberal regulation and store productivity. However, a dynamic structural model is needed to allow for flexibility in how regulation influences productivity, to model a controlled productivity process, and to disentangle the effect of regulation on productivity from that on demand.

4 A dynamic structural model of productivity and regulation

Stores maximize their expected discounted profits and choose inputs and investments based on current productivity ω_{jt} , capital stock k_{jt} , wages w_{jt} , and other exogenous observed local market characteristics.¹⁶ Store productivity follows a controlled first-order Markov process, $P(d\omega_{jt}|\omega_{jt-1}, r_{mt-1})$, where r_{mt-1} measures entry regulation in local market m during period $t - 1$. Two stores that exhibit the same current productivity but that exist in markets with different regulations will differ in their future productivity realizations because they face different incentives to improve their productivity given the stringency of regulation. More liberal regulation might result in better distributions of future productivity, conditional on current productivity, i.e., $P(\cdot)$ is stochastically increasing in r_{mt-1} for a given ω_{jt-1} . The service production function for store j is

$$q_{jt} = \tilde{\beta}_l l_{jt} + \tilde{\beta}_k k_{jt} + \tilde{\omega}_{jt} + \tilde{\epsilon}_{jt}, \quad (1)$$

¹⁶Lowercase letters represent variables in logs.

where q_{jt} is the log of service output by store j at time t , and $\tilde{\beta}_l$ and $\tilde{\beta}_k$ are the true technology parameters.¹⁷ The unobserved $\tilde{\omega}_{jt}$ is technical productivity, and \tilde{e}_{jt} represents shocks to service output that are not predictable during the period in which inputs can be adjusted and in which stores make exit decisions.

In services industries such as retail, measuring service output is difficult. The best proxy for service output is value-added, which controls for the stock of products that are bought from wholesalers. However, value-added implies that we will underestimate the labor and capital parameters without controlling for prices (Klette and Griliches, 1996; Foster et al., 2008).¹⁸ Based on the available Swedish data, we assume that the demand function has a negative slope and that stores operate in a market with horizontal product differentiation, where η_s (< -1 and finite) captures the elasticity of substitution among products in subsector s :

$$p_{jt} = p_{st} + \frac{1}{\eta_s} q_{jt} - \frac{1}{\eta_s} q_{smt} - \frac{1}{\eta_s} \xi_{jt}, \quad (2)$$

where p_{jt} is the log of service output price for store j , p_{st} is the log of service output price in subsector s , q_{smt} is the log of service output in subsector s in local market m , and ξ_{jt} represents demand shocks to store j . Using (2) to control for prices in (1), we obtain

$$y_{jt} = \beta_l l_{jt} + \beta_k k_{jt} - \beta_q q_{smt} - \frac{1}{\eta_s} \xi_{jt} + \omega_{jt} + e_{jt}, \quad (3)$$

where $y_{jt} = q_{jt} + p_{jt} - p_{st}$ is deflated value-added; $\beta_{l,k} = \left(1 + \frac{1}{\eta_s}\right) \tilde{\beta}_{l,k}$ are the coefficients for labor and capital, respectively; $\beta_q = \frac{1}{\eta_s}$ is the coefficient for market

¹⁷Service output does not include the products that are purchased from the wholesaler and sold in the store, i.e., intermediate inputs. This model is easy to apply to a general specification. For example, translog with neutral efficiency across stores would perform equally well.

¹⁸If products are perfect substitutes, deflated sales are a perfect proxy for unobserved quality-adjusted output. In manufacturing, Foster et al. (2008) analyze the relationships among physical output, revenue, and firm-level prices in the context of market selection and find that productivity based on physical quantities is negatively correlated with store-level prices, whereas productivity based on revenue is positively correlated with store-level prices.

output; and $\omega_{jt} = \left(1 + \frac{1}{\eta_s}\right) \tilde{\omega}_{jt}$ and $e_{jt} = \left(1 + \frac{1}{\eta_s}\right) \tilde{e}_{jt}$ are technical productivity and shocks to service production adjusted for the elasticity of demand, respectively. We use aggregate value-added in subsector s in local market m as a proxy for q_{smt} (Klette and Griliches, 1996). When estimating (3), we must control for unobserved demand shocks ξ_{jt} and unobserved productivity shocks ω_{jt} . This demand system allows for one elasticity of substitution for all stores within each subsector, i.e., a constant markup over marginal cost by subsector s , $\left(\frac{\eta_s}{1+\eta_s}\right)$, and the Lerner index is $\frac{1}{|\eta_s|}$.

The nature of the available data and the difficulty of measuring prices in retail require that we use a simple demand system, and we argue that our empirical application supports a constant elasticity of demand (CES) demand system.¹⁹ The Swedish retail industry has characteristics reflecting monopolistic competition, i.e., each local market consists of many stores such that a price change in one store likely has a minor impact on the market price and the regulation process. Most local markets consist of 5-12 stores per subsector, and there are no local monopolies. We analyze each store as a separate unit. Thus, we focus on the substantial share of stores operating as independent or franchise units.²⁰

To control for unobserved demand shocks, we decompose ξ_{jt} into two parts, $\xi_{jt} = \mathbf{z}'_{mt}\boldsymbol{\beta}_z + u_{jt}^d$, where \mathbf{z}'_{mt} represents the observed local demand characteristics (population, population density and income) and u_{jt}^d represents the remaining unobserved, store-specific demand shocks. In addition, we remove the immediate effect of regulation on prices by including current regulation r_{mt} in \mathbf{z}'_{mt} . Controlling

¹⁹A common and well-known challenge in retail studies is the measurement of prices owing to the complexity of products and product assortments. In our setting, measuring prices is even more difficult because we recover productivity for all stores, which requires separate price measures for each store. We are not aware of any study on retail productivity and market structure that combines detailed store-level information for all stores and store-level prices.

²⁰A careful and complete demand analysis applying the Berry et al. (1995) (BLP) framework requires store-level price data and product characteristics for all stores, which is unfortunately unavailable in many datasets.

for unobserved demand shocks in (3), we obtain

$$y_{jt} = \beta_l l_{jt} + \beta_k k_{jt} - \beta_q q_{smt} - \frac{1}{\eta_s} \mathbf{z}'_{mt} \boldsymbol{\beta}_z - \frac{1}{\eta_s} u_{jt}^d + \omega_{jt} + e_{jt}. \quad (4)$$

To identify technical productivity separately from demand, we assume that u_{jt}^d are i.i.d. shocks and that collapse into e_{jt} . If there are correlated demand shocks, u_{jt}^d enters in ω_{jt} , and we identify quality-adjusted productivity, i.e., the sum of technical productivity and remaining demand shocks (see online Appendix D). An important difference between technical and quality-adjusted productivity is the interpretation of the results, i.e., the remaining demand shocks that are included in ω_{jt} . For simplicity, we refer to ω_{jt} as productivity in what follows, even if we might measure quality-adjusted productivity.

Regulation and the productivity process. Regulation influences the productivity of incumbent stores with a one-year lag that reflects the time required for stores to cut slack and change features, such as management, to increase their productivity.²¹ The reduced-form empirical evidence for labor productivity and multi-factor productivity presented in Section 3 (Table 6) supports the modeling of regulation in the productivity process. Productivity ω_{jt} follows a first-order controlled Markov process:

$$\omega_{jt} = E[\omega_{jt} | \omega_{jt-1}, r_{mt-1}] + v_{jt} = g(\omega_{jt-1}, r_{mt-1}) + v_{jt}, \quad (5)$$

where r_{mt-1} measures entry regulation in local market m during period $t - 1$ and v_{jt} represent shocks to productivity that are mean independent of all information known at t . Shocks v_{jt} can be understood as the realization of uncertainties that are naturally linked to productivity. The conditional expectation function $E[\omega_{jt} | \omega_{jt-1}, r_{mt-1}]$ is unobserved by the econometrician (but known to the store) and is approximated by the nonparametric function $g(\omega_{jt-1}, r_{mt-1})$.

²¹For example, similar approaches are adopted to analyze productivity and R&D (Aw et al., 2011; Doraszelski and Jaumandreu, 2013) as well as productivity and trade liberalization (De Loecker, 2011).

A key advantage of our model over models in previous work on regulation and productivity is that regulation affects store productivity in a flexible manner, i.e., $g(\omega_{jt-1}, r_{mt-1})$ captures the differential impact of more liberal regulation on store productivity conditional on both productivity and the stringency of local market regulation. After observing the regulation level, stores immediately adjust their prices to secure their market share and customers as captured by r_{mt} in \mathbf{z}'_{mt} . The lagged effect of regulation is on productivity. In the case of quality-adjusted productivity, the previous degree of local market regulation r_{mt-1} affects both prices and productivity, and these effects cannot be separated from one another.

Mechanism for the impact of entry regulation on productivity. We expect more liberal regulation to influence productivity in several ways. Entry regulations can improve productivity directly if new stores are highly productive. Moreover, because entry regulations constitute barriers to entry, we expect reduced regulatory stringency to increase competition. Incumbents then face incentives to increase their productivity to survive and to maintain their market share (X-inefficiency), reflecting an indirect effect of entry regulation on productivity. Stores can increase their productivity in several ways, such as investments in new technology (e.g., scanner techniques, distribution centers) and improvements in management.²² We provide reduced-form evidence of a positive relationship between regulation and competition measures in our data. Table 5 presents the regression results for the entry rate and HHI with different regulation measures, local market controls, and year and subsector fixed effects included as explanatory variables. The coefficient for regulation is positive and statistically significant at the 1 percent level in all specifications. The results indicate that a positive relationship exists between competition and regulation, suggesting that this mechanism might play a role in our data.

²²Goolsbee and Syverson (2008) provide an example how the threat of entry influences incumbent behavior.

Incumbent responses to changes in regulatory stringency are complex in retail, relating to, for instance, store type, product assortment, hours of operation, prices, distribution systems, new investments, and education. Modeling these responses requires a complex setting based on dynamic games. This paper aims to measure the net effect of entry regulation on productivity rather than to model all channels through which this effect occurs. The advantage of a single agent framework is that it allows for an improved understanding of store heterogeneity. By contrast, endogenizing competition by considering strategic interactions in a dynamic game framework markedly complicates the analysis and imposes additional assumptions (Pakes et al., 2007; Dunne et al., 2013; Maican and Orth, 2013).²³

Entry regulation is exogenous in the productivity process such that individual stores do not affect the outcome of regulation or form expectations about the stringency of future regulation. Although we employ a two-step estimation procedure (as discussed below), which alleviates endogeneity concerns regarding regulation, we examine the robustness of our findings by using an instrumental variable approach in the controlled Markov regression. We discuss the endogeneity of regulation in the estimation and robustness sections.²⁴

Productivity and labor demand. To estimate the service production function (4), we must proxy for unobserved productivity. To recover productivity from the service production function (4), we use the labor demand function from each store profit maximization problem and a good measure of store-specific wages, i.e., $l_{jt} = \tilde{l}_t(\omega_{jt}, k_{jt}, w_{jt}, q_{smt}, \mathbf{z}_{mt})$, where $\tilde{l}_t(\cdot)$ is an unknown function strictly increasing in ω_{jt} , and w_{jt} is the log of the wage rate at the store level (Levinsohn and Petrin, 2003; Doraszelski and Jaumandreu, 2013). Assuming that labor is a static

²³For example, dynamic games raise issues about the functional forms of cost functions, multiple equilibria, equilibrium selection mechanisms, and aggregation to reduce computational complexity. Concerns about aggregation and computational complexity, for instance, are pertinent in analyses of local retail markets that consist of many stores.

²⁴To render regulation endogenous in a structural framework, we need detailed information about regulation in each local market. However, the lack of such institutional details can be substituted with additional modeling assumptions, which we expect to influence the final results.

and variable input based on current productivity is not as restrictive in the retail industry as in many other industries. Indeed, part-time employment is common, the share of skilled labor is relatively low, and stores frequently adjust their labor use according to variation in customer flows.²⁵

We assume that wages follow an exogenous process. The scalar unobservable assumption, i.e., that productivity ω_{jt} is the only unobservable in $\tilde{l}_t(\cdot)$, is required for identification. The strictly increasing condition mentioned above also holds under the simple CES demand system (Levinsohn and Melitz, 2006). Because stores set wages and because both part-time and temporary contracts are common in retail, the identification relies on variation in store-specific wages.

Estimation. The estimation of the service production function proceeds in two steps. By inverting the labor demand function to recover productivity and by substituting this function into the service production function, we obtain $y_{jt} = \phi_t(l_{jt}, k_{jt}, w_{jt}, q_{smt}, \mathbf{z}_{mt}) + \epsilon_{jt}$, where ϵ_{jt} is the sum of demand and output shocks and $\phi_t(\cdot) = \beta_l l_{jt} + \beta_k k_{jt} - \beta_q q_{smt} - \frac{1}{\eta_s} \mathbf{z}'_{mt} \beta_z + \omega_{jt}$. In the first step, we estimate $\hat{\phi}_t(\cdot)$, which separates productivity ω_{jt} from i.i.d. shocks to output ϵ_{jt} according to $\omega_{jt}(\boldsymbol{\beta}) = \hat{\phi}_t(\cdot) - \beta_l l_{jt} - \beta_k k_{jt} + \beta_q q_{smt} + \frac{1}{\eta_s} \mathbf{z}'_{mt} \boldsymbol{\beta}_z$, where $\boldsymbol{\beta} = (\beta_l, \beta_k, \beta_q, \eta_s, \boldsymbol{\beta}_z)$.²⁶

In the second step, we non-parametrically regress $\omega_{jt}(\boldsymbol{\beta})$ on a polynomial expansion of order three in $\omega_{jt-1}(\boldsymbol{\beta})$ and r_{mt-1} to obtain shocks v_{jt} . The moment $E[v_{jt}|l_{jt-1}] = 0$ identifies β_l . The assumption that stores determine their capital investments at $t - 1$ implies that the coefficient for capital β_k is identified by $E[v_{jt}|k_{jt}] = 0$. Parameters η_s and $\boldsymbol{\beta}_z$, are identified by $E[v_{jt}|q_{smt-1}] = 0$ and $E[v_{jt}|\mathbf{z}_{mt-1}] = 0$, respectively. When local entry regulation r_{mt} is a component of \mathbf{z}_{mt} , a moment based on r_{mt} can be used to identify the coefficient for r_{mt} .²⁷

²⁵Online appendix E considers a static and parametric labor demand function (Doraszelski and Jaumandreu, 2013).

²⁶We use a third-order polynomial expansion in its arguments and estimate $\hat{\phi}_t(\cdot)$ by using OLS.

²⁷Nevertheless, we cannot truly separate the effect of regulation on prices, as regulation might have lagged effects on prices. If one is concerned that current regulation is correlated with shocks to the service production function ϵ_{jt} and demand in the first step of the estimation, one can use moments based on r_{mt-1} or the average stringency of regulation in other local markets.

The identification of the impact of entry regulation on productivity relies on current productivity shocks v_{jt} being mean independent of regulation in the previous period. The nature of the structural semiparametric model helps address the possible endogeneity of regulation on productivity. Further, removing the effect of current regulation and other local market characteristics from the sum of demand and production shocks ϵ_{jt} in the first step reduces endogeneity concerns in the second step (i.e., when estimating the productivity process) and clarifies our identification of the impact of entry regulation on productivity. However, if the remaining productivity shocks v_{jt} are still correlated with regulation in the previous period (e.g., they include demand shocks correlated with the regulation measure), we might overestimate the impact of more liberal regulation on productivity. In this case, we can identify the coefficient for regulation in the second step by using moment conditions based on Hausman-type instruments (Hausman, 1997), e.g., average regulatory stringency in other local markets.²⁸

The β parameters are estimated by minimizing the sample analogue of the moment conditions discussed above. Because nonlinearities exist in the coefficients, we use the Nelder-Mead numerical optimization method to minimize the GMM objective function

$$\min_{\beta} Q_N = \left[\frac{1}{N} W' v(\beta) \right]' A \left[\frac{1}{N} W' v(\beta) \right], \quad (6)$$

where A is the weighting matrix defined as $A = \left[\frac{1}{N} W' v(\beta) v'(\beta) W \right]^{-1}$ and W is the matrix of instruments. Using the estimated $\hat{\beta}$ coefficients, we obtain the recovered productivity, $\omega_{jt} = y_{jt} - \hat{\beta}_l l_{jt} - \hat{\beta}_k k_{jt} + \hat{\beta}_q q_{smt} + \frac{1}{\hat{\eta}_s} \mathbf{z}'_{mt} \hat{\beta}_z$.²⁹

²⁸Our empirical results are robust to the use of Hausman-type instruments to control for the possible endogeneity of regulation.

²⁹One can also recover productivity based on estimates using the labor demand function, $\omega_{jt} = \hat{\phi}_t(\cdot) - \hat{\beta}_l l_{jt} - \hat{\beta}_k k_{jt} + \hat{\beta}_q q_{smt} + \frac{1}{\hat{\eta}_s} \mathbf{z}'_{mt} \hat{\beta}_z$. Although mean productivity is similar, the greater variance is expected with the service production function. To compare the results across various proxy estimators, much of the previous productivity research provides results based on production functions, e.g., Olley and Pakes (1996), Akerberg et al. (2006), and De Loecker (2011).

4.1 Service production function estimates

Table 7 presents the results from the service production function estimates for each subsector. We focus on the OLS estimator and main specification (NP_{lm}), which employs a controlled Markov process for productivity and controls for both prices and local market conditions. Returns to scale ($\beta_l + \beta_k$) are higher after we control for prices (Klette and Griliches, 1996).³⁰ For all subsectors, the labor coefficient (β_l) is smaller after we control for prices in the main specification (column (2) in Table 7) than in the OLS specification, which indicates that we have successfully controlled for simultaneity bias. In the main specification, the book, computer and electronic subsectors exhibit the highest labor elasticity, whereas the book and furniture subsectors exhibit the highest capital elasticity.

The average estimated demand elasticity across subsectors in NP_{lm} is -4.12, with a range between -8.30 (hardware) and -1.26 (watches). The corresponding average markup (price over marginal cost) across subsectors is 1.86, with a range between 1.13 (hardware) and 4.76 (watches). These findings are consistent with previous results based on U.S. data (Hall, 1988). A high degree of product differentiation might explain the low values (in absolute terms) of demand elasticity in some subsectors, such as furniture. Clothing, electronics, and sports are characterized by relatively low markups and high exit rates (Table 2). The estimated parameters allow us to compute productivity and to evaluate the impact of entry regulation on productivity by using the estimated Markov process.

³⁰The returns to scale are higher after we control for prices in NP_{lm} than in the OLS specification and the nonparametric specification without price controls (NP_l in online Appendix F.2). Our results are consistent with extant research showing increasing returns to scale in retail. We expect increasing returns to scale in services owing to geographic dispersion, multi-market contact, and an increasing returns to scale “illusion” that is attributable to self-services, i.e., the volume of self-services is larger than the amount of services performed by stores (Ofer, 1973). Few studies use production function approaches to analyze returns to scale in retail trade, though Ofer (1973), Bairam (1994) and Maican and Orth (2009) are exceptions.

5 Results of the structural analysis

Based on the estimated productivity of each store, we quantify the changes in productivity with more liberal regulation. Specifically, we analyze store productivity for the pooled sample (Section 5.1), store productivity by subsector (Section 5.2), aggregate productivity in local markets (Section 5.3), and heterogeneity in productivity depending on both store and market size (Section 5.4). We then provide robustness checks (Section 5.5).

5.1 Store-level productivity

Before turning to the results for the specification that is fully consistent with our dynamic model, we pool all stores and subsectors and estimate the following simple linear specifications by using the OLS estimator: (a) an $AR(1)$ productivity process, $\omega_{jt} = \alpha_0 + \alpha_1\omega_{jt-1} + \alpha_r r_{mt-1} + f_t + f_s + \nu_{jt}$; and (b) $\omega_{jt} = \alpha_0 + \alpha_r r_{mt-1} + \mathbf{z}_{mt}\boldsymbol{\alpha}_z + f_t + f_s + \mu_{jt}$, where ν_{jt} and μ_{jt} are i.i.d shocks that are not correlated with entry regulation r_{mt-1} or local market characteristics \mathbf{z}_{mt} . In addition, the f_t and f_s are fixed effects for year and subsector, respectively. The first specification includes previous productivity, controls for the persistence of productivity, and extends the analysis from Section 3 by allowing regulation to exert a dynamic effect on productivity.

We use estimated store productivity from our main specification NP_{lm} (Section 4) and the OLS estimator (Section 3.2). The same regulation measures and control variables from the reduced-form regressions presented in Table 6 are utilized. The results allow us to connect the reduced-form regressions with the specification that is entirely consistent with the dynamic model presented in Section 5.2.³¹

Table 8 shows that the coefficient for regulation is positive in all specifications

³¹Note that specifications (a) and (b) are not entirely consistent with the model (NP_{lm}) that relies on a flexible approximation of the productivity process based on previous productivity and regulatory stringency.

and statistically significant for all specifications using productivity from our proxy estimator (NP_{lm}).³² The marginal effects of an additional PBL approval, with population density held constant, increases productivity by an average of 1.67 percent for the OLS specification and 0.42 percent for NP_{lm} . The fourfold greater increase for the OLS specification is consistent with the theoretical predictions because this productivity measure includes both productivity and prices. Productivity in NP_{lm} is less persistent than productivity in the OLS estimator, which suggests that we have successfully isolated parts of the persistent demand shocks from ω_{jt} . The structural approach implicitly controls for simultaneity and selection biases that affect productivity measures and marginal effects owing to nonlinearity in the productivity process. Overall, the results of the pooled sample and linear specification provide evidence of a positive association between regulation and store-level multi-factor productivity.

5.2 Store-level productivity by subsector

To quantify the effects of more liberal entry regulation on future store productivity more accurately, we use the regression results from the controlled Markov process and approximate $g(\omega_{jt-1}, r_{mt-1})$ by using a third-order polynomial expansion in previous productivity ω_{jt-1} and regulation r_{mt-1} .³³ An advantage of our dynamic framework is that we obtain marginal effects for each store in the data, which allows us to recover the full distribution of the effect of entry regulation on productivity in each local market.

To keep the presentation of the structural results tractable, we measure regulation as the number of approvals divided by the population density, which allows for exogeneity and captures both market size and density (both of which are important

³²The standard errors are clustered at the local market level.

³³A liberal regulatory environment does not serve as a productivity growth machine in local markets because increased competition also induces exit, which implies a decrease in product differentiation that negatively affects consumers. Thus, our model only measures the net effect.

in retail). The results are robust to the use of the our alternative measures of regulation discussed in Section 2, i.e., the number of approved PBL applications divided by the number of stores, the number of approved PBL applications divided by the number of zoning plans, the regulation index, and the number of PBL approvals (see online Appendix F).

Table 9 documents the heterogeneity in the change in store productivity with one additional approval (with population density held constant). As the table shows, store productivity is higher when regulation is more liberal. This result holds for all subsectors. Store productivity increases by 1-4 percent on average for most subsectors. In addition, productivity changes vary across stores, as indicated by the standard deviations of the marginal effects. The largest average marginal effects (2-4 percent) of entry regulation on productivity are obtained for toys, footwear, textile, and books. This pattern of results may be due to the relatively high net exit rates in these subsectors, which force incumbents to increase their productivity (Table 2).

We also present the support of the impact of a more liberal regulation on productivity. For each subsector, the support is determined based on 1,000 simulated values from all parts of the productivity distribution. The support provides additional information regarding the heterogeneity of productivity changes with more liberal regulation and complement the mean marginal effects. The large and positive upper bounds in footwear, books, and textiles indicate that some stores realize substantial productivity gains from more liberal regulation in these subsectors and confirm the relatively large mean marginal effects in these subsectors.³⁴

³⁴To investigate the sensitivity of the marginal effects of regulation on productivity in our structural approach, we utilize simulation. The estimated results of the controlled productivity process based on productivity recovered from a service production function with different coefficients for labor and capital than those in our main specification (NP_{lm}) exhibit changes in the marginal effects of regulation on productivity. The results of the simulations and the comparison of the nonparametric two-step approach and simple parametric specification emphasize the importance of using sophisticated methods to accurately estimate productivity and to evaluate changes produced by regulation. These simulations are available from the authors upon request.

5.3 Aggregate local market productivity

A key task for policymakers is to assess the change in aggregate local market productivity when entry regulation becomes more liberal. Quantifying the cost of regulations in terms of changes in local market productivity is a first step toward a more complete welfare analysis of entry regulations. The magnitude of these effects can thus be compared with other demand and supply side aspects that local authorities should evaluate when considering the consequences of a new entrant. For example, in Sweden, municipalities must consider the availability of stores and store products, prices, market shares, and traffic.

We evaluate the change in aggregate local market productivity in each subsector caused by one additional PBL approval (with population density held constant). To do so, we sum the marginal effect of all stores for each local market and year, which is based on the actual previous level of productivity for stores and level of regulation, with output market shares as weights. The results indicate the change in weighted aggregate local market productivity if regulation were to become more liberal.

Table 10 provides the distribution of annual changes in local market productivity from one additional approval. The effect of regulation exhibits substantial heterogeneity across local markets and subsectors. For example, the textile, electronics, and watches subsectors are characterized by relatively high dispersion of changes in local market productivity with more liberal regulation. The median local market productivity increases by 1-5 percent in the textile, footwear, books, and toys subsectors but only by 0.2-0.6 percent in the other subsectors.³⁵

The large increases in aggregate productivity for the textile, footwear, and book subsectors are clearly connected to high net exit rates (Table 2) and low growth

³⁵For a median market, 10 applications are approved, which represents a non-trivial change in productivity of 2-56 percent.

in average value-added (Table B.2 in online Appendix B). Further, the increase in aggregate productivity in the toys and computers subsectors is associated with high shares of entry of large stores (in absolute numbers and relative to the share small store entry; Table 2) and high mean growth in value-added and number of employees (Table B.2 in online Appendix B).

5.4 Heterogeneity across stores and local markets

A central advantage of our structural framework is that we can obtain the full distribution of marginal effects of more liberal regulation, enabling us to carefully investigate heterogeneous productivity responses across stores and local markets. To evaluate heterogeneity in marginal effects across store sizes, we divide the sample into small and large stores based on the median of the number of employees. Table 11 displays the median marginal effects of one additional approval on small and large store productivity and indicates whether the medians of these groups are equal. As the table shows, an additional PBL approval yields a greater increase in productivity for small stores than for large stores. Specifically, median productivity increases by 1 additional percentage point for small stores compared with large stores. This result holds for seven of the eleven subsectors. The difference in the productivity increase between small and large stores is smaller in the furniture, sports, and hardware subsectors, while approaching zero for the clothing sector.

Because an additional approval increases competition, small incumbents must improve their productivity to a greater extent than larger incumbents to remain in the market. A test of equal median marginal changes in productivity due to more liberal regulation shows that we can reject the null of equal medians between small and large stores for all subsectors.³⁶

Heterogeneity in marginal effects across local markets can depend on the market

³⁶To test whether the medians are equal for small and large stores, we follow recent studies in statistics and use quantile regressions with a group indicator.

size. To investigate the possible effects of market size, we analyze the weighted aggregate local market productivity in markets with populations below and above the median (Table 11). We find that the increase in aggregate local market productivity increases due to an additional PBL approval is greater in small local markets than in large local markets. Specifically, median local market productivity increases by 1-3 additional percentage points in small markets compared with large markets for the textile, footwear, toys, and watches subsectors. The difference between small and large markets is smaller for the remaining subsectors.³⁷

We thus find evidence of larger productivity improvements from more liberal regulation in small markets than in large markets. In other words, allowing a new store to enter the market creates more intense competition in local markets that consist of fewer stores (incumbents) such that the competitive intensity from entrants declines with the number of stores. A test of equal median marginal effects between large and small markets rejects the null of equal medians for ten of the eleven subsectors.

5.5 Robustness checks

In this section, we evaluate the sensitivity of our empirical results. For this purpose, we conduct a variety of robustness checks on the results from the service production function and controlled productivity process. Overall, the main results are found to be robust in a large number of specification tests.

Alternative measures of regulation. To demonstrate the robustness of our regulation variable, we consider the following alternative measures of entry regulation: number of PBL approvals divided by the number of stores, number of PBL approvals divided by the number of zoning plans, index variables that combine our

³⁷We cannot reject the null of equal medians for the electronics subsector. For the computers subsector, the increase in median productivity is greater in large markets than in small markets. This result might be due to the tendency of firms in this industry to locate in large and expanding cities rather than in rural environments.

data sources, and number of PBL applications (see Section 2 for details). All the results are presented in online Appendix F.

First, Tables F.1 and F.2 (online Appendix F.1) present estimates of the service production function and descriptive statistics for the impact of regulation for each subsector when we use the number of approved PBL applications divided by the total number of stores and the number of approved PBL applications divided by the number of zoning plans as entry regulation measures. Table F.3 displays the weighted aggregate marginal effects of an additional approval computed for both regulation measures evaluated at the observed number of stores and number of zoning plans in a market. The findings indicate that the positive impact of more liberal entry regulation on productivity is robust to the use of alternative measures of regulation.

Second, we use the regulation index described in Section 2 and alternative weighting schemes for this regulation index. Online Appendix F.2 presents the marginal effects for individual stores and local markets when the regulation index increases by one standard deviation. The results also indicate that more liberal regulation increases store productivity for virtually all subsectors. Specifically, median store productivity increases by 2-4 percent on average for most subsectors with a one standard deviation increase in the regulation index.

Third, we use the number of PBL approvals to measure the degree of regulation. Online Appendix F.3 presents a detailed analysis of the results with the number of approved PBL applications as the entry regulation measure. The results from using the number of PBL approvals of retail stores for the sample of 163 (of 290) local markets are available from the authors upon request. The results show that the approval of one additional application by local authorities increases the productivity of the median store by 1.5-2.6 percent for most subsectors, which represents a relatively larger effect than that obtained from regulation measures unrelated to

local market size.³⁸ Importantly, our main results regarding the improvement in productivity are robust to the use of a regulation measure that is not normalized by market size. Aggregated across all local markets, this improvement translates to annual subsector economic costs ranging from 2.8 million euros (toys) to 194 million euros (furniture).³⁹ These figures are not trivial, corresponding to nearly 10 percent of the annual capital investments made in the Swedish retail trade. For the 1996-2002 period, the aggregate subsector costs range from up to 20 million euros (toys) to 1,361 million euros (furniture). Finally, the positive effect of regulation on productivity is robust to the use of political preferences as a measure of regulatory stringency.⁴⁰

Endogeneity of regulation. Our proposed framework allows us to control for the possible endogeneity of regulation. In the Markov process regression, we control for the endogeneity of our regulation measures by using the average value of the regulation measures in other local markets as instruments. The use of this type of instrument is valid if regulation is not subject common productivity shocks across local markets. Suzuki (2013) argues that finding a valid instrument for the regulation index is challenging and thus does not control for endogeneity. In our setting, it is important to note that our two-step estimation approach alleviates endogeneity concerns regarding the regulation measure. However, our approach allows us to form moments that control for the possible endogeneity of regulation during both stages of the service production function estimation if endogeneity concerns remain. Furthermore, this approach also allows us to control for the endogeneity of wages and aggregate quantity during the first step of the estimation.

Selection. When we control for selection in our main specification, NP_{lm} yields

³⁸This result is expected because the number of approvals is positively correlated with market size.

³⁹Numbers are in 2012 values, where 1 EUR=9.01 SEK and 1 EUR=1.30 USD. In these calculations, we multiply the average annual cost per store by the average number of stores in the subsector over the period 1996-2002.

⁴⁰These results are available from the authors upon request

similar parameter estimates for the service production function and similar magnitudes of the marginal effects of more liberal regulation on productivity (Olley and Pakes, 1996).

Alternative estimators. As noted in the discussion of the results of the service production function estimates, we find evidence that controlling for local market demand and simultaneity bias is crucial, as not controlling for local market demand yields decreasing returns to scale (NP_l in Appendix F.2). The service production function parameters change as predicted by theory when we control for simultaneity and prices.

An attractive candidate for proxy of productivity in our nonparametric two-step approach of estimating the service production function is a parametric labor demand function (Doraszelski and Jaumandreu, 2013). As key differences from the main specification, this parametric approach forms moments based on shocks to both service production and demand, and the estimation proceeds in one step. The parametric approach is explained in Appendix E. The main result that more liberal regulation increases productivity holds when we use this parametric approach (the results are available from the authors upon request).

6 Conclusions

This paper investigates the impact of regulation on productivity. Although this issue is important to both researchers and policymakers, extant research is still in the initial stages of quantifying the effects of regulation on productivity in various industries. We use a dynamic structural model to estimate multi-factor productivity and to evaluate how it varies with the degree of local market entry regulation in retail trade. Specifically, we analyze how more liberal regulation changes store future productivity and weighted aggregate productivity in local markets. Our model controls for local market demand and allows for different technologies across subsec-

tors. The advantages of our approach are that we can use a controlled productivity process with respect to regulation and can allow for flexibility in how stores react to regulatory changes by considering the responses of each store. We obtain the full distribution of productivity responses from all stores, which is an important initial step in evaluating the welfare of regulatory changes.

Insight into the extent to which entry regulations affect productivity in retail is particularly important because retail markets have undergone dramatic changes related to the use of technology (e.g., scanners, barcodes, online credit card processing), inventory and price managements, and distribution networks. In addition, structural changes have led to fewer, larger stores. The combination of information technology improvements and economies of scale, density, and scope has dramatically altered the retail sector, which plays an important role in economic activity today. Despite these striking trends, few studies have investigated the effect of local regulations on productivity in local markets by using a structural framework. The proposed approach is general and can be applied to retail and services industries in other countries.

The empirical application relies on detailed data on all stores in Swedish retail market, which is representative of many retail markets in the OECD in terms of market structure and regulation, for the period 1996-2002. The results reveal that there are increasing returns to scale in the majority of subsectors of the Swedish retail industry. Further, substantial heterogeneity in the effect of regulation on productivity is found across stores and local markets. Across all subsectors, store productivity increases by 1.8 percent on average from one additional approved application. In local markets, median aggregate productivity increases by 0.2-5 percent. Moreover, one additional approval increases median productivity by 1 additional percentage point for small stores compared with large stores, and the increase in aggregate local productivity is 1-2 percentage points higher in small markets than in large markets. Our results are robust when we use different measures of regulatory

stringency and control for the endogeneity of the regulation measure.

Our results are relevant to competition policy through entry regulation in the OECD. We find that more liberal use or design of entry regulations stimulates productivity in local markets. However, these gains must be weighted against environment costs, increased traffic, and access for target consumers, such as pensioners. Our findings contribute to an improved understanding of the frequently debated sources of the productivity gap between Europe and the U.S.

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Table 1: Descriptive statistics, Swedish retail trade 1996-2002

	1996	1997	1998	1999	2000	2001	2002	$\Delta(\%)$
Sales	244.0	250.0	264.0	278.0	295.0	302.0	326.0	34.0
Value added	43.1	44.7	47.8	50.0	54.8	54.9	59.2	37.0
Investment	3.4	3.4	3.6	4.5	5.3	4.8	5.0	47.0
Capital stock	10.0	11.0	12.0	15.0	17.0	19.0	20.0	100.0
No. of employees	144.0	144.0	151.0	149.0	155.0	158.0	159.0	10.0
No. of stores	21,464.0	20,787.0	20,318.0	20,085.0	20,169.0	19,618.0	19,233.0	-10.0

NOTE: Sales (excl. VAT), value added, investment and capital stock are measured in billions of 1996 SEK (1 USD=6.71SEK, 1 EUR=8.63 SEK). Number of employees is measured in thousands.

Table 2: Entry and exit by subsector 1996-2002

Subsector	Entry rate			Exit rate			Net entry	No. of stores	No. of obs.
	Small	Large	Total	Small	Large	Total			
Textiles	0.071 (0.021)	0.007 (0.003)	0.078 (0.021)	0.129 (0.027)	0.007 (0.003)	0.136 (0.026)	-0.055 (0.047)	355 (41)	2,486
Clothing	0.082 (0.014)	0.011 (0.001)	0.094 (0.016)	0.097 (0.014)	0.013 (0.003)	0.110 (0.015)	-0.015 (0.021)	2,467 (72)	17,273
Footwear	0.063 (0.008)	0.008 (0.003)	0.071 (0.008)	0.093 (0.011)	0.011 (0.004)	0.104 (0.011)	-0.033 (0.018)	591 (41)	4,142
Furniture	0.094 (0.016)	0.012 (0.003)	0.106 (0.015)	0.097 (0.018)	0.014 (0.005)	0.111 (0.020)	-0.003 (0.019)	1,603 (23)	11,227
Electronics	0.066 (0.020)	0.007 (0.002)	0.073 (0.020)	0.087 (0.015)	0.009 (0.002)	0.096 (0.017)	-0.023 (0.024)	1,291 (62)	9,037
Hardware	0.080 (0.013)	0.018 (0.003)	0.099 (0.013)	0.073 (0.013)	0.019 (0.006)	0.092 (0.016)	0.008 (0.020)	1,313 (22)	9,193
Books	0.062 (0.014)	0.009 (0.002)	0.071 (0.012)	0.100 (0.012)	0.016 (0.008)	0.116 (0.012)	-0.044 (0.019)	561 (50)	3,929
Sports	0.096 (0.026)	0.011 (0.002)	0.107 (0.025)	0.095 (0.009)	0.013 (0.004)	0.108 (0.010)	0.001 (0.014)	1,101 (10)	7,707
Watches	0.054 (0.019)	0.004 (0.004)	0.058 (0.019)	0.075 (0.016)	0.006 (0.004)	0.081 (0.015)	-0.021 (0.019)	594 (26)	4,160
Toys	0.078 (0.018)	0.025 (0.011)	0.103 (0.024)	0.112 (0.028)	0.025 (0.009)	0.137 (0.023)	-0.027 (0.047)	228 (13)	1,599
Computers	0.112 (0.024)	0.025 (0.008)	0.137 (0.031)	0.108 (0.006)	0.031 (0.008)	0.139 (0.008)	-0.001 (0.027)	1,176 (26)	8,237

NOTE: The figures represent mean (standard deviation) by subsector and year for the period 1996-2002. Stores are defined as small if the number of employees is below the median and large otherwise.

Table 3: Local market characteristics

	Mean	Std. dev.	25th perc.	Median	75th perc.
A. Regulation measures					
Number of approved applications	25.808	34.700	5.000	10.000	28.000
Approvals by number of zoning plans	0.063	0.031	0.043	0.062	0.081
Approvals by number of stores	0.099	0.088	0.052	0.076	0.120
Approvals by population density	0.278	0.703	0.044	0.123	0.267
B. Other local market characteristics					
No of stores	392.368	653.586	53.000	117.000	286.000
No of stores per subsector	30.873	61.069	4.000	8.000	22.000
No of stores per capita	2.410	0.574	2.066	2.426	2.813
Population	147.933	233.067	24.314	54.426	118.581
Population density	597.600	1203.614	26.390	69.310	233.500
Income	175.178	36.752	153.401	165.668	182.341

NOTE: This table displays summary statistics for the regulation measures and other local market characteristics. Municipalities (290 in total) are used as local markets. To measure local market regulation, we use (i) the number of PBL approvals divided by the population density, (ii) the number of PBL approvals divided by the number of stores, and (iii) the number of PBL approvals divided by the total number of zoning plans. Income is the average income at the local market level. Population and income are reported in thousands of persons and thousands of 1996 SEK. The number of stores per capita is the number of stores per 1,000 people. Population density measures the number of persons per 1,000 m^2 .

Table 4: Correlations between regulation measures and local market characteristics

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) Approvals by number of zoning plans	1.00	-	-	-	-	-	-	-
(2) Approvals by number of stores	0.52	1.00	-	-	-	-	-	-
(3) Approvals by population density	0.23	0.22	1.00	-	-	-	-	-
(4) No of stores per capita	0.04	-0.41	0.27	1.00	-	-	-	-
(5) Income	0.08	0.15	-0.17	-0.15	1.00	-	-	-
(6) Income growth	0.11	0.01	-0.03	0.02	0.45	1.00	-	-
(7) Entry rate	0.06	-0.02	-0.04	0.04	0.03	0.01	1.00	-
(8) Herfindahl index	-0.07	0.21	-0.10	-0.20	-0.09	-0.04	-0.05	1.00

NOTE: This table displays the correlations between the regulation measures and local market characteristics. To measure local market regulation, we use (i) the number of PBL approvals divided by the population density, (ii) the number of PBL approvals divided by the number of stores, and (iii) the number of PBL approvals divided by the total number of zoning plans. The Herfindahl index (HHI), which is constructed using market shares based on store sales, and entry rates are calculated for each subsector, local market, and year.

Table 5: Reduced-form regressions: The impact of entry regulation on local market competition

	Number of PBL approvals divided by the population density		Number of PBL approvals divided by the number of stores		Number of PBL approvals divided by the number of zoning plans	
	HHI (1)	Entry rate (2)	HHI (1)	Entry rate (2)	HHI (1)	Entry rate (2)
Regulation	-0.006* (0.004)	0.019*** (0.004)	-0.012 (0.026)	0.426*** (0.035)	-0.105* (0.059)	0.268*** (0.074)
Market controls	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Subsector FE	Yes	Yes	Yes	Yes	Yes	Yes
No. of obs.	12,528	12,528	12,528	12,528	12,528	12,528
R^2	0.565	0.061	0.565	0.259	0.580	0.008

NOTE: Standard errors at the local market level are presented in parentheses. HHI is the Herfindahl index, which is constructed using market shares based on store sales. The HHI and entry rate are calculated for each subsector, local market, and year. Local market controls include population, population density, income, and market fixed effects. To measure local market regulation, we use lagged values of (i) the number of PBL approvals divided by the population density, (ii) the number of PBL approvals divided by the number of stores, and (iii) the number of PBL approvals divided by the total number of zoning plans. Significance: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

Table 6: Reduced-form regressions: The impact of regulation on store multi-factor productivity and labor productivity

	Number of PBL approvals divided by the population density				Number of PBL approvals divided by the number of stores				Number of PBL approvals divided by the number of zoning plans			
	OLS (1)	Labor (2)	OLS (3)	Labor (4)	OLS (1)	Labor (2)	OLS (3)	Labor (4)	OLS (1)	Labor (2)	OLS (3)	Labor (4)
Regulation	0.078* (0.041)	0.014*** (0.004)	0.076* (0.041)	0.014*** (0.004)	0.754* (0.441)	0.084** (0.036)	0.713** (0.307)	0.085*** (0.024)	0.352 (0.857)	0.266*** (0.085)	0.352 (0.856)	0.267*** (0.085)
Income growth	0.317 (0.680)	0.446*** (0.099)	0.191 (0.732)	0.446*** (0.103)	0.735 (0.760)	0.448*** (0.098)	0.414 (0.765)	0.447*** (0.093)	0.313 (0.677)	0.440*** (0.097)	0.178 (0.729)	0.439*** (0.101)
Income (Q25-Q50)			0.027 (0.100)	0.017 (0.014)			-0.068 (0.089)	0.018 (0.015)			0.027 (0.100)	0.018 (0.014)
Income (Q50-Q75)			0.018 (0.154)	0.026 (0.016)			-0.093 (0.153)	0.027 (0.017)			0.021 (0.154)	0.027* (0.016)
Income (Q75-Q90)			-0.030 (0.168)	0.024 (0.019)			-0.137 (0.191)	0.025 (0.018)			-0.027 (0.167)	0.025 (0.018)
Income (over Q90)			0.158 (0.184)	0.025 (0.021)			0.204 (0.177)	0.027 (0.020)			0.167 (0.184)	0.027 (0.021)
Other market controls	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Subsector FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. of obs.	45,155	45,155	45,155	45,155	45,155	45,155	45,155	45,155	45,155	45,155	45,155	45,155
R^2	0.033	0.161	0.033	0.156	0.027	0.161	0.028	0.156	0.033	0.161	0.033	0.157
$mfpBL$ (%)	1.71	0.10	1.67	0.03	0.19	0.02	0.18	0.02	0.07	0.04	0.10	0.07

NOTE: For each regulation measure, the dependent variable is multi-factor productivity in columns (1) and (3) and labor productivity in columns (2) and (4). Multi-factor productivity is computed as the residual from estimating the service value function by OLS, i.e., $\omega_{jt} = y_{jt} - \hat{\beta}_0 - \hat{\beta}_k k_{jt}$. Labor productivity is measured as log of value-added per total number of employees. The Herfindahl index, constructed based on store's sales, and entry rates are calculated for each subsector, local market and year. Additional local market controls include population and population density. Population, population density, and income are in logs. Income percentiles are defined at the local market level. Below the 25th percentile is used as reference group. Clustered standard errors at the local market level are in parentheses. To measure local market regulation, we use lagged values of (i) the number of PBL approvals divided by the population density, (ii) the number of PBL approvals divided by the number of stores, and (iii) the number of PBL approvals divided by the total number of zoning plans. $mfpBL$ is the marginal effect of one additional approved PBL application. Significance: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

Table 7: Service production function estimates: nonparametric approach

	<i>OLS</i>		<i>NP_{lm}</i>				No. of obs.
	Labor (1)	Capital (2)	Labor (1)	Capital (2)	Demand	Markup	
Textiles	0.821 (0.020)	0.123 (0.010)	0.526 (0.001)	0.149 (0.002)	-5.109	1.24	1,548
Clothing	0.757 (0.007)	0.120 (0.004)	0.675 (0.001)	0.127 (0.001)	-6.960	1.16	13,308
Footwear	0.735 (0.011)	0.121 (0.006)	0.586 (0.003)	0.209 (0.001)	-2.393	1.71	3,207
Furniture	0.814 (0.008)	0.135 (0.005)	0.256 (0.018)	0.333 (0.003)	-1.599	2.66	8,674
Electronics	0.821 (0.008)	0.144 (0.004)	0.557 (0.006)	0.097 (0.001)	-5.462	1.22	7,087
Hardware	0.782 (0.007)	0.189 (0.004)	0.674 (0.008)	0.163 (0.005)	-8.306	1.13	7,474
Books	0.737 (0.012)	0.149 (0.007)	0.502 (0.001)	0.129 (0.001)	-1.654	2.52	3,054
Sports	0.744 (0.009)	0.141 (0.005)	0.610 (0.002)	0.165 (0.001)	-6.443	1.18	6,051
Watches	0.804 (0.012)	0.101 (0.006)	0.398 (0.006)	0.250 (0.009)	-1.265	4.76	3,242
Toys	0.682 (0.021)	0.216 (0.013)	0.451 (0.012)	0.183 (0.003)	-3.102	1.47	1,269
Computers	0.795 (0.009)	0.212 (0.006)	0.721 (0.008)	0.160 (0.003)	-3.120	1.47	6,676

NOTE: The dependent variable is log of deflated value-added. Standard errors are reported in parentheses. Labor is measured as number of full-time adjusted employees. All regressions include year dummies. *OLS* is ordinary least square regression. *NP_{lm}* is two-step estimation using a nonparametric labor demand function as proxy for productivity and controlling for imperfect competition. The estimated coefficients include elasticity, i.e., $(1 + \frac{1}{\eta})\beta_l$ for labor and $(1 + \frac{1}{\eta})\beta_k$ for capital. The *NP_{lm}* specification includes previous year's the number of approved PBL over the population density in the productivity process (Section 4), current capital stock and previous labor are used as instruments and standard errors are computed using Akerberg et al. (2011). Market output is measured as the market share weighted output in the municipality. Demand refers to the elasticity of substitution. Markup is defined as price over marginal cost.

Table 8: Reduced-form regressions: The impact of regulation on store multi-factor productivity from OLS and semiparametric estimator

	Number of PBL approvals divided by the population density				Number of PBL approvals divided by the number of stores				Number of PBL approvals divided by the number of zoning plans			
	OLS (1)	NP_{lm} (2)	OLS (3)	NP_{lm} (4)	OLS (1)	NP_{lm} (2)	OLS (3)	NP_{lm} (4)	OLS (1)	NP_{lm} (2)	OLS (3)	NP_{lm} (4)
Regulation	0.032** (0.015)	0.013*** (0.004)	0.076** (0.041)	0.019** (0.010)	0.134 (0.125)	0.227*** (0.037)	0.713** (0.307)	0.592*** (0.128)	-0.734** (0.306)	0.770*** (0.093)	0.352 (0.856)	0.565*** (0.058)
Previous productivity	0.843*** (0.003)	0.797*** (0.008)			0.843*** (0.003)	0.699*** (0.007)			0.843*** (0.003)	0.722*** (0.008)		
Income growth			0.191 (0.732)	-2.662*** (0.288)			0.414 (0.765)	0.880*** (0.122)			0.178 (0.729)	0.501* (0.287)
Income (Q25-50)			0.027 (0.100)	-0.023 (0.023)			-0.068 (0.089)	-0.070*** (0.023)			0.027* (0.100)	-0.046*** (0.012)
Income (Q50-75)			0.018 (0.154)	-0.168*** (0.034)			-0.093 (0.153)	-0.222*** (0.024)			0.021 (0.154)	-0.075*** (0.014)
Income (Q75-90)			-0.030 (0.188)	-0.235*** (0.039)			-0.137 (0.191)	-0.301*** (0.052)			-0.027* (0.167)	-0.099*** (0.022)
Income (over Q90)			0.158 (0.184)	-0.160*** (0.044)			0.204 (0.177)	-0.269*** (0.041)			0.167 (0.184)	-0.101*** (0.029)
Other market controls	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Subsector FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. of obs.	45,155	45,155	45,155	45,155	45,155	45,155	45,155	45,155	45,155	45,155	45,155	45,155
R^2	0.709	0.999	0.033	0.998	0.709	0.974	0.028	0.947	0.709	0.991	0.033	0.991
$mf^{PBL}(\%)$	0.69	0.27	1.67	0.42	0.03	0.05	0.18	0.14	-0.21	0.23	0.10	0.16

NOTE: The dependent variable is the multi-factor productivity estimated by OLS in columns (1) and (3) and by semiparametric estimator NP_{lm} in columns (2) and (4). Multi-factor productivity is computed as the residual from estimating the service value function by OLS, i.e., $\omega_{jt} = y_{jt} - \hat{\beta}_0 - \hat{\beta}_1 l_{jt} - \hat{\beta}_2 k_{jt}$. Labor productivity is measured as log of value-added per total number of employees. Additional local market controls include population and population density. Population, population density, and income are in logs. Income percentiles are defined at the local market level and the 25th percentile is used as reference group. Clustered standard errors at the local market level are in parentheses. To measure local market regulation, we use lagged values of (i) the number of PBL approvals divided by the population density, (ii) the number of PBL approvals divided by the number of stores, and (iii) the number of PBL approvals divided by the total number of zoning plans. mf^{PBL} is the marginal effect of one additional approved PBL application. Significance: *p<0.1; **p<0.05; ***p<0.01.

Table 9: The impact of regulation on store productivity using nonparametric estimation

Subsector	Mean	Std.dev.	Adj. R^2	No. of obs.	Support
Textile	3.25	3.88	0.402	1,079	[-4.26 9.08]
Clothing	0.21	0.18	0.284	9,677	[0.07 0.72]
Footwear	4.33	2.88	0.936	2,386	[-0.18 9.68]
Furniture	0.94	1.19	0.610	6,336	[-2.80 1.78]
Electronics	0.44	1.56	0.474	5,290	[-1.03 4.46]
Hardware	0.37	0.18	0.347	5,597	[-0.09 0.56]
Books	2.04	4.16	0.594	2,261	[-3.77 10.69]
Sports	0.76	0.36	0.297	4,358	[0.50 1.79]
Watches	0.72	6.34	0.644	2,468	[-8.60 12.71]
Toys	4.39	1.41	0.457	899	[3.51 8.97]
Computers	1.31	2.70	0.406	4,804	[-1.71 7.54]

NOTE: This table shows means and standard deviations, across local markets and years, of the median marginal effect (%) on stores' productivity when an additional PBL application is approved. The number of PBL approvals divided by the population density is used as a proxy for regulation (Section 2). Marginal effects are computed for individual stores using their observed values of previous productivity, the regulation measure and population density. The OLS estimator is used to estimate the controlled Markov process. The support is computed using 1,000 simulation draws from the estimated distribution of productivity.

Table 10: Percent changes in aggregate local market productivity from more liberal regulation

Subsector	25th perc.	Median	75th perc.	Mean
Textile	0.39	2.35	3.13	5.23
Clothing	0.22	0.34	1.06	0.53
Footwear	3.23	5.67	5.89	7.66
Furniture	0.05	0.37	1.12	1.34
Electronics	-0.45	0.00	3.55	0.47
Hardware	0.16	0.30	1.84	0.46
Books	-0.78	1.27	1.53	3.69
Sports	0.48	0.64	0.72	0.90
Watches	-2.71	0.60	1.02	3.85
Toys	3.47	4.39	3.80	5.26
Computers	-0.63	0.18	0.19	0.90

NOTE: This table displays summary statistics for the percent changes in aggregate local market productivity from an additional PBL approval. The number of PBL approvals divided by the population density is used as a proxy for regulation (Section 2). The marginal effects are computed for individual stores using their observed values of previous productivity, the regulation measure and population density. Municipalities (290 in total) are used as local markets. Marginal effects for individual stores are used (Table 9) with output market shares as weights.

Table 11: Aggregate impact of more liberal regulation by store and market size

	Panel A: Median impact at the store level			Panel B: Median impact at the market level		
	No. of employees		Test H_0 : Equal medians	Population		Test H_0 : Equal medians
	Below median (%)	Above median (%)		Below median (%)	Above median (%)	
Textile	4.22	2.88	Reject	3.25	1.75	Reject
Clothing	0.19	0.23	Reject	0.35	0.27	Reject
Footwear	5.41	4.77	Reject	6.03	4.37	Reject
Furniture	1.03	0.93	Reject	0.99	0.41	Reject
Electronics	1.13	0.13	Reject	-0.11	0.01	Accept
Hardware	0.42	0.36	Reject	0.41	0.22	Reject
Books	2.59	1.03	Reject	2.91	0.09	Reject
Sports	0.69	0.59	Reject	0.80	0.49	Reject
Watches	1.60	0.51	Reject	2.10	-0.32	Reject
Toys	4.57	3.87	Reject	4.75	3.89	Reject
Computers	1.56	0.85	Reject	-0.06	0.24	Reject

NOTE: The figures present the median values of the marginal effects by by store and year (Panel A) and by market and year (Panel B). Municipalities (290 in total) represent local markets. Stores are defined as small if the number of employees is below the median and large otherwise. Local markets are defined as small if the population is below the median and as large otherwise. The number of PBL approvals divided by the population density is used as a proxy for regulation (Section 2). Marginal effects measure the percent changes in store productivity (Panel A) and aggregate local market productivity (Panel B) from an additional PBL approval. Marginal effects are computed for individual stores using their observed values of previous productivity, the regulation measure and population density. The aggregate weighted productivity in local markets is computed by using the marginal effects in Table 9 and output market shares as weights. To test whether the medians are equal for small and large stores, we follow recent literature in statistics and use quantile regressions with a group indicator.