

Superstores or Mom and Pops?

Market Size, Technology Adoption and TFP Differences

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March 24, 2008

Abstract

Most theories of total factor productivity (TFP) emphasize production-side frictions, such as barriers to technology adoption. I argue that for the retail sector, which employs around one-fifth of the private workforce, cross-country TFP differences are driven instead by demand-side factors. I hypothesize that in developing countries, the use of highly productive large-scale retail formats, such as hypermarkets and supermarkets, is limited by low household income and high household transportation costs. Thus less productive "mom and pop" stores are used more widely in poorer countries. I formalize my theory in a spatial model of technology adoption in which market size drives the mix of retail formats used and retail sector TFP. When parameterized, the model suggests that market size could account for roughly one half the retail TFP gap. I argue that policies which deter car ownership reduce the size of the market for large-scale retail stores, and I calculate that removing such policies could lead to sizeable TFP gains.

*For helpful comments I thank Andy Atkeson, Paco Buera, Ariel Burstein, Sofronis Clerides, Matthias Doepke, Bart Hobijn, Tom Holmes, Hugo Hopenhayn, Joe Kaboski, Ellen McGrattan, Gabriel Natividad, Jim Schmitz, Mark Wright, Jon Vogel, and especially Lee Ohanian, my advisor. The paper has benefitted from the comments of seminar participants at Arizona State, Chicago GSB, the Federal Reserve Board, Iowa, Maryland, the Minneapolis Fed, NYU Stern, Penn, Rochester, UC Berkeley Haas School of Business, UCLA, UC San Diego, USC Marshall, Wharton, Yale, the 2007 SED in Prague, and the Latin American TFP Conference at UCSB. For help with Mexican data I thank Marcelo Ore Vásquez and Javier Pérez Estrada, and for help with Cypriot data I thank Alexis Antoniadis and Sofronis Clerides.

1 Introduction

One of the most important questions in economics is why per-capita income is so much lower in the developing world than in advanced economies. A large body of literature in macroeconomics points to total factor productivity (TFP) differences as the primary determinant of country income differences.¹ Unfortunately, explaining TFP differences has proven challenging thus far. Most of the existing theories of TFP emphasize production-side frictions, such as barriers to technology adoption (Parente and Prescott, 1994), a lack of competitive pressure (Schmitz, 2005), or policies that misallocate resources across producers (Restuccia and Rogerson, 2007; Klenow and Hsieh, 2007).² In this paper I argue that for the retail sector, which employs around one-fifth of the private workforce, production-side distortions have little to do with measured TFP differences.³ Instead, TFP in the retail sector is driven by demand-side factors, specifically household income and household transportation costs. My paper suggests that low measured TFP in retailing in the developing world reflects largely appropriate technology adoption choices by poorer countries given their low income.

I begin by documenting that cross-country TFP differences in retailing are mostly accounted for by differences in the use of highly productive "modern" retail technologies, such as hypermarkets and supermarkets. In the U.S., modern stores employ more than three-quarters of retail-sector workers. In contrast, in developing countries, less productive "traditional" formats, such as "mom and pop" grocers and street vendors, dominate the retail industry. These compositional differences account for the bulk of the retail productivity gap between the U.S. and the developing world. Surprisingly, modern stores within developing countries are roughly as productive as those in the U.S. Thus for the retail sector at least, a theory of TFP differences should be a theory of why modern technologies are used so *infrequently* in the developing world, not why they are used *less efficiently*.

My theory is that modern retail formats require sufficiently large markets in order to recoup the fixed costs of their large-scale operations. In developing countries, rela-

¹See for example Klenow and Rodríguez-Clare (1997), Hall and Jones (1999), or Prescott (1999).

²There are numerous other ideas in this vein. Other prominent examples include worker resistance to new production methods (Clark, 1987), barriers to entry (Herrendorf & Teixeira, 2007; Parente & Prescott, 1999) or insufficient skilled labor (Acemoglu & Zilibotti, 2001; Caselli & Coleman, 2002).

³The employment share in retail trade appears similar across countries in recent history. The U.S. share of private employment has fluctuated in the range of 16% to 19% since 1975 (Bosworth & Triplett, 2004). In Mexico, retail trade in 2000 was around 16% of employment (INEGI, 2000), and in Argentina, Burstein et al (2003) report an employment share of 21% for retail and wholesale trade in 1997.

tively low income per square mile and high transport costs mean that few modern stores can be supported, and hence smaller, less-productive traditional stores prevail. I formalize this idea in a spatial model of technology adoption in which market size drives the share of inputs employed at a high-productivity modern store type and a less productive traditional store. Market size is driven by household income and transportation costs. Households may purchase automobiles, which decrease transportation costs, and thus makes them more likely to shop at the modern stores, which in equilibrium are less expensive than the traditional stores, yet further from the typical household. Thus, automobiles serve as complements to modern retailers. Retail TFP is determined endogenously in the model by the share of productive inputs employed at modern formats. The main qualitative result is that higher income leads to higher TFP in retail, as households have more purchasing power and purchase more autos, which increases the size of the market for modern stores.

I parameterize the model and use it to quantify the role of market size in explaining cross-country retail TFP differences. I find that market size can explain on the order of one half the retail TFP gap between the US and developing countries with 1/4 the US income level. I arrive at this conclusion by first calibrating the model to match such a developing country, and then hypothetically raising its income by a factor of 4 keeping all else equal. I conclude that market size is likely to be a central factor in explaining international productivity differences in retailing. Similar arguments may be applicable to other industries where market size and scale economies play a role, such as non-tradeable services.

One implication of my theory is that a new set of government policies is relevant for TFP differences. For example, policies that increase transportation costs by making car ownership more costly impede the adoption of large-scale retail stores and lower retail-sector TFP. One specific policy in this category is a ban on the imports of used cars, which is in place in a surprising number of poor countries. To highlight the potential importance of this policy, I cite evidence from an experiment in Cyprus where used-car import bans were removed and both automobile ownership and modern retailer prevalence increased in the ensuing period. Other policies can lower TFP by implicitly favoring smaller, less-productive producers. For example limited tax enforcement efforts favor small retail stores, and reduce the size of the market for modern stores.

I use the parameterized model to quantify the TFP gains from counterfactual changes in these two policies. I start with a hypothetical improvement in tax enforcement

efforts, resulting in an inability for traditional stores to evade taxes. I find TFP gains of around 10% as the mix of retail stores shifts from traditional to modern. Next, I consider policies that limit car ownership by distorting the market for automobiles. Under a hypothetical relaxation of these policies, and under plausible reductions in auto prices, I find a dramatic increase in the employment share of modern stores accompanied by TFP gains on the order of 15-30%.

Finally, I test the market-size hypothesis using geographic micro data on household income, car ownership and retail store prevalence. I employ data from the U.S and Mexico, where high-quality geographic data exists and geographic units (counties) are comparable. My main finding is that in Mexico, modern retail stores are much more common in areas with higher income per square mile than with lower income density. Richer urban areas in Mexico, where income and car ownership rates are relatively high, have retail format mixes that are similar to the U.S., with modern employment shares above 50%. In contrast, in poorer rural areas of Mexico, where income and car ownership rates are low, modern stores constitute a negligible fraction of retail employment. I also find that even in many of the least dense areas in the U.S., modern employment shares are still high. The fact that car ownership rates are also high in these areas suggest that car ownership plays a key role in determining market size. Overall, my findings provide strong support for the market-size theory.

Related Literature

My paper contributes to a growing literature trying to explain TFP by studying the allocation of inputs across producers. Banerjee and Duflo (2005) present evidence that misallocation of capital in the developing world is pervasive, and argue that it likely to be an important factor in explaining TFP differences. Restuccia and Rogerson (2007) quantify the effect of misallocation on aggregate TFP in a model where plants with heterogenous TFP levels are taxed unequally, finding that misallocation can lower TFP by 30 to 50 percent. Klenow and Hsieh (2007) use plant-level data from India and China to calculate the TFP gains from a hypothetical reduction in the dispersion of marginal products of capital across firms down to U.S. level, finding gains of 25 to 70 percent. Low TFP in these models, as in mine, come as resources are reallocated from less efficient to more efficient producers. My paper differs from these in that productivity differences in my hypothesis arise from market size differences, not from distortions on the production side.

Syverson (2004) also explores the role of market size on productivity, but through a different channel than mine, namely selection effects. He argues that larger markets

lead to more competition among producers, which drives out the least productive firms and raises average productivity. Our papers differ qualitatively in that, in my model, larger markets raise productivity because they allow for a large-scale technology with fixed costs to be used profitably. They differ quantitatively in that I find a substantially larger role for market size in driving productivity than Syverson does. As I show in the quantitative section to follow, in retail trade, larger markets lead to productivity increases at least an order of magnitude higher than the gains Syverson estimates. Another paper exploring the role of market size and productivity is by Desmet and Parente (2006), who argue that larger markets lead to less resistance to the adoption of more-productive technologies. Their paper explicitly avoids any role of fixed costs, unlike my paper which brings it front and center.

My paper also complements the recent literature on the rise of modern retail stores in the U.S. Basker (2007) and Holmes (2008) are two prominent examples that explore the rise of Wal-Mart, and Jarmin, Klimek and Miranda (2007) document the increasing importance of retail chains in the US. The paper closest to mine in focus is by Foster, Haltiwanger and Krizan (2006), who show that virtually all the labor productivity gains in retail trade in the US over the 1990s are accounted for by more productive retail establishments replacing less-productive ones.⁴ One contribution of my paper to this literature is to argue that productivity differences in retailing between the U.S. and the developing world are closely linked to the limited use of modern retail stores in poorer countries.

Finally, my paper contributes to the diverse literature which assigns household goods a central role in driving economic outcomes. Greenwood, Seshadri, and Yorukoglu (2005) posit that widespread adoption of time-saving household appliances was the driving force behind increases in the dramatic female labor force participation over the last century. Kopecky and Suen (2006) argue that the rise of suburbanization in the U.S. can be explained in large part by the rise of automobiles. Buera and Kaboski (2007, 2008) argue that a market-to-home production cycle is behind the rise of services in the U.S., with household durable goods serving as catalysts for moving service production to the household. They point out that durable goods such as cars, fridges and freezers are likely to have been important in the decline of traditional retail services. My focus on household goods as complements to more-productive

⁴The idea that the allocation of inputs across producers is a key determinate of productivity growth has found broad support. Perhaps the first such study is by Baily, Hulten, and Campbell (1992), who find a strong role for reallocation in driving productivity growth in manufacturing. The findings of Foster et al (2006) suggest that the role is more pronounced in retailing.

technologies and in driving TFP differences appears new to this literature.

The rest of this paper is organized as follows. In Section 2, I document that cross-country retail productivity differences are largely explained by composition differences. In Section 3 I use geographic micro-data to link market size differences to retail composition differences. I develop a theory of retail composition in Section 4, building on the geographic evidence, which I parameterize in Section 5, and use for policy experiments in Section 6. In Section 7 I discuss alternative explanations for the facts at hand, and I conclude in Section 8.

2 Retail Sector TFP Explained Largely by Composition

In this section I document the main empirical result of the paper, which is that differences in the composition of retail formats across countries explains a large fraction of TFP differences in the retail sector. I arrive at this result using two broad sources of data, both of which I describe in detail below. The first is the McKinsey Productivity Studies, and the second is a set of country-specific censuses of retail trade. Before delving into the results, it is worth being clear on exactly how output is measured in retailing, since conceptual and practical challenges exist in productivity measures in the services.

2.1 Measuring Output in Retailing

The output of a retail establishment is perhaps best described as "a composite bundle of services" attached to the goods being sold (Oi, 1992). Examples include assembling and displaying the array of goods for sale, supplying product information, or providing credit or warranties. This composite service is not directly measurable, however, and hence retail output is almost always constructed by deflating some measure of the value of retail output by an appropriate price measure. The output value measure used exclusively in this paper is *value added*, which is defined as the total value of sales minus the total cost of goods purchased for re-selling, and which Bailey and Solow (2001) describe as "the best simple measure of retailing output."⁵

⁵See Baily (1993) or Bosworth and Triplett (2004), for detailed discussions of the alternative output measures used in retailing including the limitations of each measure.

To allow for international comparisons, output is expressed in international dollars using a PPP exchange rate. The baseline measures are deflated by a PPP exchange rate for consumption taken from the Penn World Tables or a similar source. In Appendix A.1, I show that the paper’s empirical conclusions are robust to an alternative deflation method, namely double deflation, which some economists claim is a superior method of deflating retail output.⁶

2.2 Productivity Measures from the McKinsey Productivity Studies

In this section I present the rich disaggregate evidence on productivity differences constructed as part of the McKinsey Productivity Studies, which were conducted in the late 1990s and early 2000s by the McKinsey Global Institute working in collaboration with numerous academic economists. Martin Baily and Robert Solow, who were both collaborators in the studies, offer an overview of the McKinsey findings and more detailed description of their methods (Baily & Solow, 2001). In their study of cross-country differences in retailing, McKinsey obtained store-level data on labor inputs, sales, and the cost of goods purchased for re-sale using surveys of stores that they designed with the help of the economists who served as consultants.⁷

The productivity measure used in the McKinsey studies is value added per worker, where labor input is measured as total hours worked by paid and unpaid workers. To allow direct comparisons with the U.S., productivity measures are deflated using PPP exchange rates for consumption goods, or for food when the focus is specifically on the food retail sector. McKinsey computes labor productivity for two types of retailers: “traditional” and “modern,” which cover all establishments in the industry. Modern stores are comprised of hypermarkets, supermarkets, convenience stores, specialty stores, and department stores, and are characterized primarily by their use of advanced inventory and distribution systems. Traditional stores consist of street vendors, open-air markets, and counter stores (a.k.a. mom and pop shops). These stores are typically associated with less sophisticated distribution techniques and less division of labor – indeed many traditional stores are run by a single entrepreneur.

Figure 1 displays output per worker by type of establishment and in the retail sector as a whole for the U.S. and three developing countries, Thailand, Turkey and Poland.

⁶See, for example, the discussion in Bosworth and Triplett (2004), chapter 8.

⁷The complete set of reports can be found at www.mckinsey.com/mgi/rp/CSPROductivity/. The studies I employ are Brazil (1995) and Russia (1996) for food retailing, and Poland (1999a), Thailand (1999b), and Turkey (2001) for overall retailing.

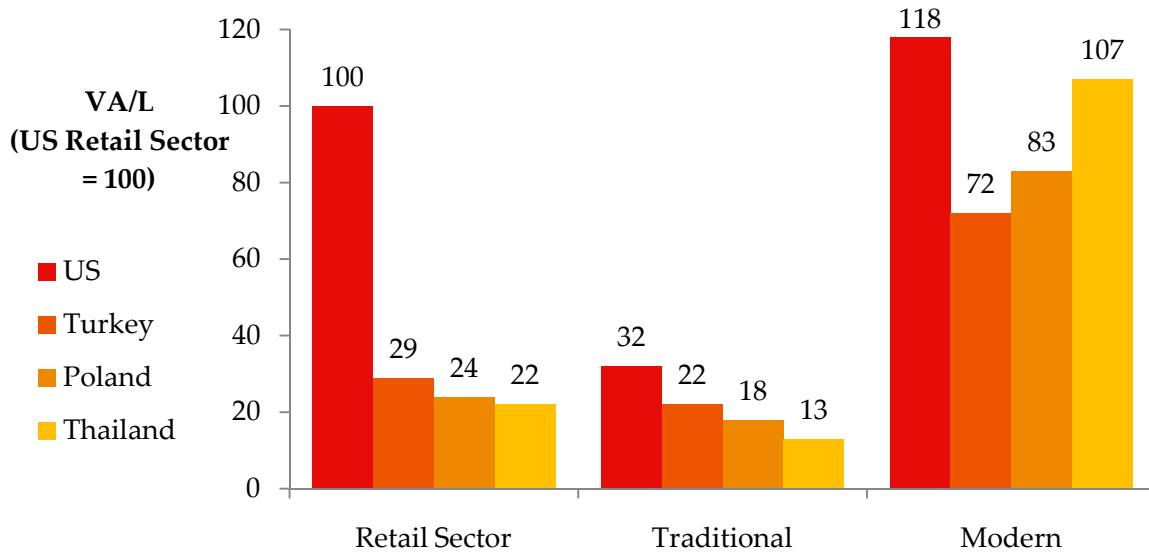


Figure 1: Labor Productivity by Type of Retail Store.

The left-hand set of bars show output per worker for the retail sectors of each country, with the U.S. normalized to 100. As is commonly seen in cross-country productivity comparisons using aggregate or sectoral data, output per worker in the U.S. is higher than the developing countries by a factor of around 4. The second and third sets of bars take us below the surface of the sectoral-level data, and show labor productivity by type of store. Perhaps surprisingly, the productivity level of modern retailers is almost as high in the developing countries as in the US. Thailand has value added per worker of around 107% of the US average, just slightly below the US modern store average, while Turkey and Poland are just below at around 80% of the US average. Traditional stores have low labor productivity in all countries, and a gap exists between the US and the developing countries.⁸ Nevertheless, the within-format productivity differences are small compared to the cross-format differences.

The relative parity of modern retailers in the developing world and the US is surprising, given the vast productivity gap in the aggregate, and given that (to the best of my knowledge) no other study has documented that the most productive firms in developing countries are roughly on par with the most productive in the US. One rea-

⁸McKinsey also conducted a similar analysis in three other developing countries that I'm aware of: Brazil, Russia, and India. For Brazil and Russia only the food retail sector was studied and the studies found similar results to the ones presented here. For India, however, retailers at all levels had extremely low output per worker: 20% of the US level in modern stores and just 3% in traditional stores, with an average labor productivity of 9% of the US level. According to McKinsey, this is because of government policies that (1) totally restrict foreign direct investment in the retail sector, and (2) forces all retailers to hire extra "un-needed" labor.

son why this finding might be true in retail, and not necessarily other sectors, is that many of the modern retailers present in the developing world are in fact operated by European or US chains.⁹ Given that so many modern retailers are in fact operated by developed-country firms, it seems reasonable that these firms can operate their technology at home and abroad at a comparable productivity level.

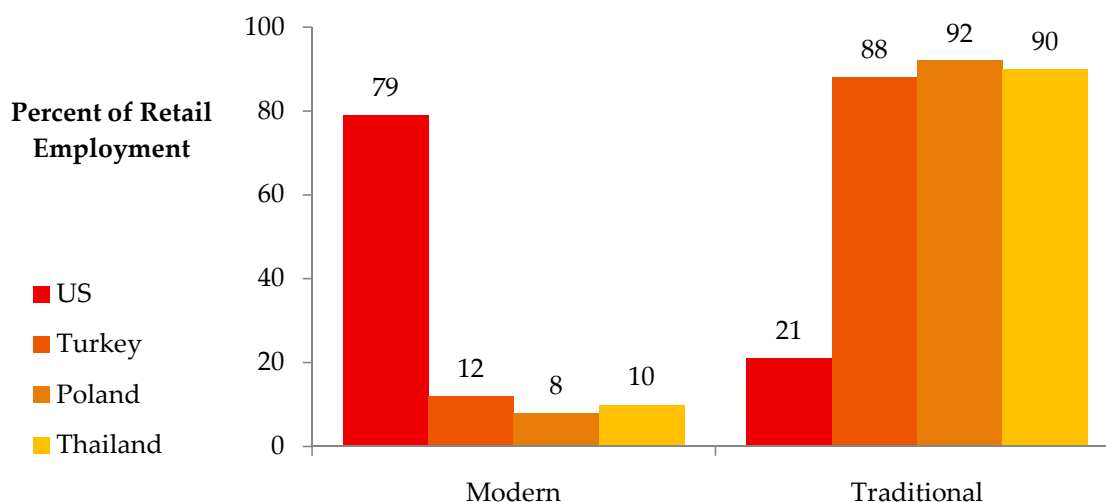


Figure 2: Employment Composition in Retailing.

So why is retail-sector output per worker 4 times higher in the U.S., even though productivity gaps by type of store are relatively small? The answer is found in Figure 2, which displays the share of employment in each type of technology in each country. The compositional differences in these countries are striking, with the modern producers commanding nearly 80% of the labor inputs in the the U.S., and less than 10% in the developing countries.¹⁰ Of course the exact opposite holds for traditional producers, which completely dominate the sector in poor countries. The two figures together imply that the retail productivity gap between the U.S. and the developing world is largely explained by *compositional differences*: i.e the low employment share of modern retailers in the developing countries compared to the US.

⁹For example, the French retailer Carrefour has extensive operations in Poland, Turkey and Brazil, while Wal-Mart is the leading retailer in Mexico.

¹⁰Western Europe is only slightly behind the U.S. in its prevalence of modern retailers. Baily and Solow (2001) report that the modern stores generate around 70-75% of total retail sales in Germany, France, the U.K., and the Netherlands, compared to around 85% in the U.S. See page 165, table 5.

2.3 Productivity Measures using Retail Censes

One of the main limitations of the McKinsey studies is the lack of data on non-labor inputs, and hence an inability to construct TFP measures for each type of technology. This is important given the evidence that modern stores use non-labor inputs, such as cash registers or scanners, more intensively than traditional stores.¹¹ Another limitation is that the McKinsey data is not publicly available, and their retail format definitions are fairly informal. In this section I address each of these shortcomings using publicly available data from economic censuses of retail establishments.

Following most studies measuring TFP in the macroeconomics literature, I posit a Cobb-Douglas production function. In order to capture the fact that a major portion of the final product sold by retail stores are intermediate goods purchased by the retailers, I nest the Cobb-Douglas function in Leontief production function. Formally, let $j \in \{M, T\}$ index the type of technology used (i.e. modern or traditional), and let i index a country. Output $Y_{i,j}$ is given by

$$Y_{i,j} = \min[A_{i,j}L^{\gamma_j}K^{1-\gamma_j}, X] \quad (1)$$

where L is labor input; K is interpreted broadly as inputs of capital equipment, capital structures, and land; $A_{i,j}$ is TFP; γ_j is the labor share in technology j ; and X is the intermediate good. One might think of X as a box of shirts purchased by the retail store, and $Y_{i,j}$ as the shirts on a rack in the store available for purchase by the customer. Value added is given by

$$VA_{i,j} = (p_{i,j} - p_{i,x})Y_{i,j} \quad (2)$$

where $p_{i,j}$ and $p_{i,x}$ are the output price and input price in country i in technology j . TFP relative to US can then be written as

$$\frac{A_{i,j}}{A_{US}} = \frac{VA_{i,j}/L_{i,j}}{VA_{US}/L_{US}} \cdot \frac{\mu_{US}}{\mu_{i,j}} \cdot \frac{(K_{US}/L_{US})^{1-\gamma_{US}}}{(K_{i,j}/L_{i,j})^{1-\gamma_j}} \quad (3)$$

where $\mu_{i,j} = \frac{p_{i,j} - p_{i,x}}{p_{i,x}}$ is the percent gross margin in country i , technology j . Variables with US subscripts represent values for the US retail sector as a whole. Unfortunately, disaggregated input data for US retail establishments are not publicly available, which precludes by-format TFP measures for the US.

¹¹For example, Foster, Hatwanger and Krizan (2006) report a ratio of capital equipment to labor around 50% larger in larger retail establishments than smaller ones.

The data used to compute TFP come from the Bureau of Economic Analysis (BEA) GDP-by-industry accounts for the US, the 1999 *Censo Comercial* for Mexico, and the 2002 *Business Trade and Services Survey* for Thailand. The latter two surveys include representative surveys of retail establishments, which allow for generalization to the entire sector. Labor input is measured as the total number of paid and unpaid employees.¹² I proxy for a modern store by an establishment with more than 20 workers, leaving a traditional store to be one with fewer than 20 workers. Capital is measured as the reported book value of capital equipment, structures, and land. I deflate output and the capital stock using the PPP exchange rates for consumption and investment (respectively) from the Penn World Tables. Data appendix A.1 shows that the results are robust to a double deflation procedure.

In principle the labor shares can be pinned down using wage and output data. In practice, however, dividing the wage bill by value added will not yield plausible measures of the labor share in traditional stores since such a large fraction of their workers are unpaid. Instead, I calculate their labor shares using the traditional stores' first order conditions and the labor shares of the largest stores. The details of these calculations are available in Appendix A.2. I end up with estimates of the labor shares of 0.50 in modern stores, 0.71 in traditional stores, and 0.60 in the US.

Computing relative TFP ratios when the labor shares are not equal requires that one take a stand on the units in which inputs are measured (Bernard and Jones, 1996). I choose to normalize the units of capital such that the US capital-labor ratio is unity. The interpretation of the TFP ratio $\frac{A_{ij}}{A_{US}}$ then becomes the ratio of output per worker in country i and technology j to output per worker in the US, when both use the US capital-labor ratio. Other plausible normalizations, such as setting the capital-labor ratio of the developing-country modern stores to one, give a slightly different interpretation, but do not substantively affect the results.

Figure 3 displays the results for TFP by type of establishment and in the retail sector as a whole for the U.S. and Mexico and Thailand. The left-hand set of bars shows TFP for the retail sectors of each country, with the U.S. retail sector normalized to 100. As in the McKinsey studies, the findings suggest that large productivity differences occur in the retail sectors of the US and the developing world. More specifically, sector TFP is roughly 1/3 to 1/2 the US level. More importantly, the results confirm

¹²The inclusion of unpaid workers is crucial as so many retailers in the developing world have no paid employees. On the other hand, the lack of data on hours worked is not ideal, as the use of part time employees is more common in larger stores (see e.g. Oi, 1992), which would understate the relative TFP of modern stores.

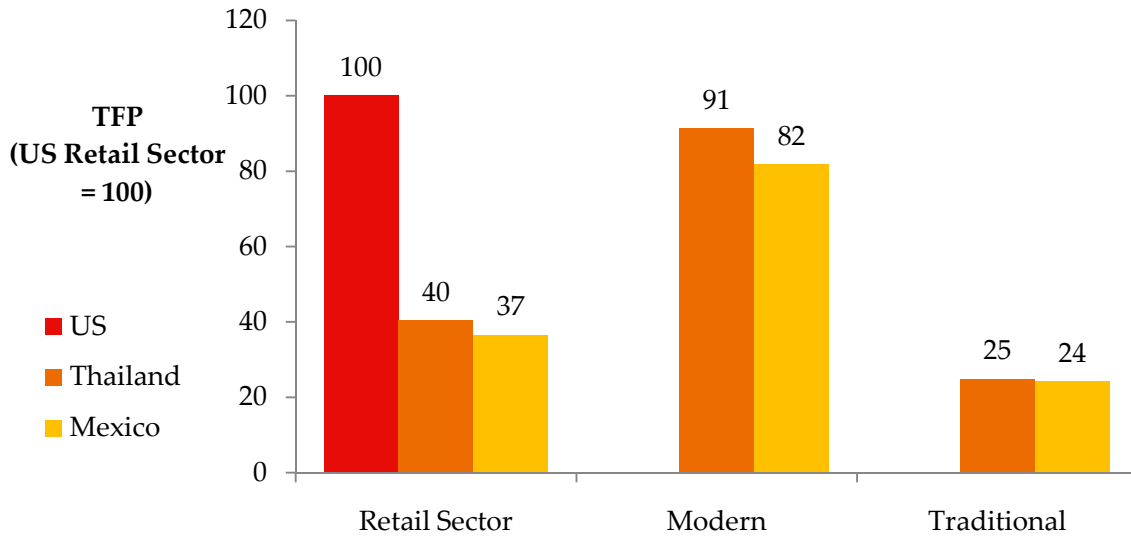


Figure 3: TFP by Type of Retail Establishment.

that TFP is in fact quite high in modern stores in the developing countries: modern stores in both Mexico and Thailand have TFP roughly on par with the US average. Traditional stores have TFP levels at around 1/4 of the US level. The relative parity of productivity levels between Mexico and Thailand in each format type gives weight to the idea that the two technologies are roughly equally productive no matter where they are operated. Importantly, these findings provide strong evidence that labor productivity differences are driven in large part by TFP differences.¹³

2.4 Quantifying the Role of Composition

The main result of this section is that composition differences drive the bulk of TFP differences in retailing. I conclude by formally quantifying the role of composition. In addition to the countries already studied so far, I add McKinsey data for the food retail sectors of Brazil and Russia, plus labor productivity measures constructed from the 2002 *Censo de Comércio* from Brazil. Table 1 shows actual retail productivity level (either VA/L or TFP) in each country studied, and a hypothetical productivity level assuming that the fraction of employment in modern stores equalled the US fraction. In other words, the table shows the hypothetical productivity level that would result

¹³The modern and traditional employment shares computed using the census data are very similar to those computed in the McKinsey Studies. The census data shows modern employment shares of 19% and 24% in Mexico and Thailand.

from adopting the modern technology to the US level, while keeping productivity the same in each technology.

COUNTRY	PRODUCTIVITY MEASURE	DATA SOURCE	RETAIL PRODUCTIVITY, ACTUAL (US=100)	RETAIL PRODUCTIVITY, UNDER US MODERN SHARE	PERCENT OF RETAIL PRODUCTIVITY GAP CLOSED
Mexico	TFP	Census (1998)	37	69	53%
Thailand	TFP	Census (2001)	40	77	64%
	Y/L	McKinsey (2001)	22	87	84%
Brazil	Y/L	Census (2002)	24	46	28%
	Y/L	McKinsey (1996) (Food Retail)	14	43	33%
Poland	Y/L	McKinsey (1999)	24	62	50%
Turkey	Y/L	McKinsey (2001)	29	69	57%
Russia	Y/L	McKinsey (1995) (Food Retail)	23	67	56%

Table 1: Composition and Retail Productivity Differences

The table suggests that composition explains at least 50% of the TFP differences, and perhaps more in labor productivity. In Mexico and Thailand, using the US's share of employment in modern stores would result in TFP of 69% and 77% of the US level respectively, compared to 37% and 40% as current. Similar findings hold for the other countries using labor productivity measures, which we have seen largely reflect TFP. The only outlier is Brazil, in which composition explains less, at around 1/3 of labor productivity differences. This is because measured modern store labor productivity is a bit lower in Brazil than the other countries, at just under 60% of the US average. The overall implication of the empirical findings is that in order to explain TFP differences in retail, what is needed is a theory of why modern retail stores are used so *infrequently* in the developing world, not why they are used less efficiently there than in the US.

3 Modern Stores Are Located in the Largest Markets

I conclude the empirical part of the paper with spatial evidence serves to motivate the demand-side theory of technology adoption that I present in the following section.

The theory argues that modern stores are used infrequently in poor countries because they lack sufficient market size for widespread operation. In this section I document evidence that within developing countries, most modern stores are located in the largest markets, defined by the highest income per square mile and car ownership rates. I provide the details of my calculations in Appendix [A.3](#).

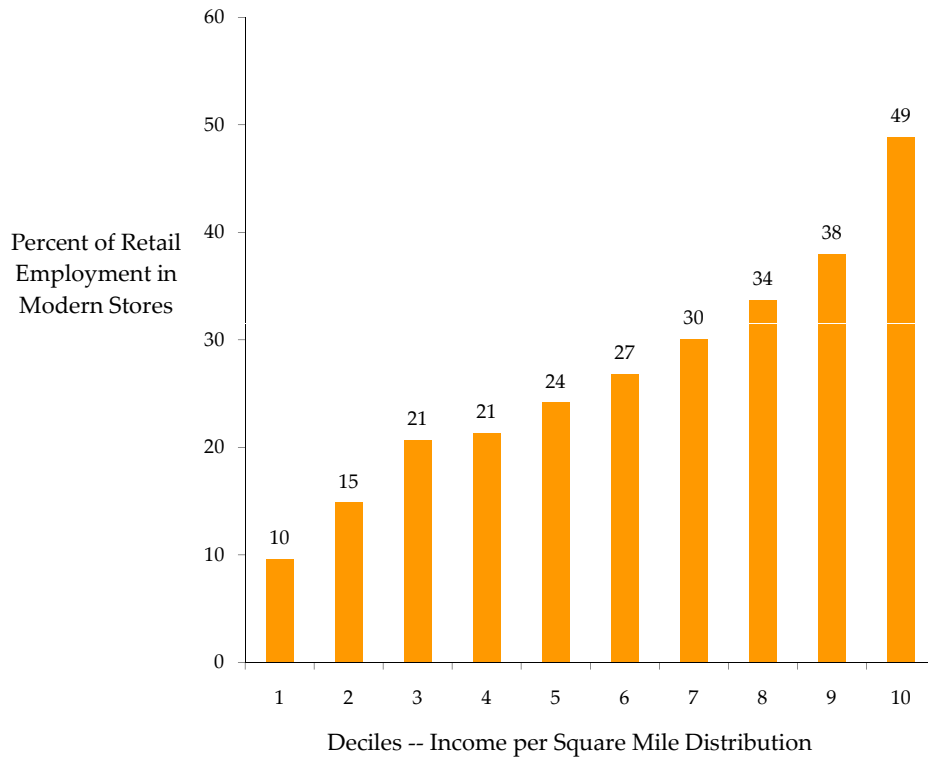


Figure 4: Modern Store Prevalence and Market Size in Mexico

Figure 4 presents a summary of my county-level (*municipio*-level) findings from Mexico. For each county, I computed the total income per square mile using micro data from the 2000 Mexican Census. The figure shows the modern employment share by quintile of the income density distribution. I measure the modern store employment share as the fraction of food retail employment in supermarkets. As is clear from the picture, modern stores are used much more intensively in the largest markets. In the largest Mexican markets, many of which are in or around Mexico City and Guadalajara, the modern employment share is around 50%, which is well closer to the U.S. level than the smallest markets, with modern shares of less than 20%.

These findings provide a challenge to the “barriers to adoption” theory for retailing, in addition to supporting the market-size theory advanced in this paper in the

section to follow. If barriers were really what drove modern store use, the findings presented in this analysis would suggest that barriers must be much stronger in the smallest markets than the biggest, a proposition for which there is no support that I am aware of. The present findings also challenge other theories of retail technology adoption, a number of which I discuss further in Section 7.

4 A Spatial Model of Technology Adoption in Retailing

The empirical findings of the paper imply that in order to explain retail TFP differences, we need a theory of why the mix of modern and traditional retail formats varies so much between richer and poorer countries. In this section I develop such a theory based on the idea that market size limits the use of modern stores. I then use the model to quantify the importance of this market-size mechanism in explaining cross-country retail TFP differences, and to quantitatively assess potentially TFP-raising policies.

4.1 Households & Spatial Structure

Households are evenly distributed along the circumference of a circle with circumference normalized to unity (Salop, 1979). The measure of households is also set to unity.¹⁴ I depart from the standard Salop-Hotelling model by adding consumer optimization over how much to buy, where to shop, and whether or not to reduce transportation costs by purchasing an automobile. I also add heterogeneity in household income, which allows the model to generate a much richer range of behavior in the cross section of households in equilibrium. Formally, households receive income exogenously, which they draw from a distribution $G(y)$ with support on $(0, \infty)$. Households at each point along the circle draw from the same distribution $G(y)$. Positing exogenous income allows me to focus on the household choice of which producer type to shop from, which is central to determining the composition of technologies used and hence TFP.

Households spend their income on a consumption good, which they buy from stores located on the circle, a superior good denoted c_s , and automobiles, denoted A and

¹⁴The advantage of placing households on a circle rather than on a line, as in the better-known Hotelling (1929) model, is that with a circle one is not faced with the tedious special cases that come with households and firms near the edge of the line.

satisfying $A \in \{0, 1\}$. Households that have a car get around the circle by driving, and the remainder get around "by bus" at a slower rate, which will be explained shortly. For expositional purposes I refer to households as A -households if they have a car, and B -households if they are ride the bus. The car and superior good are available exogenously at prices p_A and p_s .

4.2 Modern and Traditional Retail Technologies

Two different retailing technologies are available: modern (M) and traditional (T), which each use labor as their only input. I refer to these technologies as "stores." Letting j index the store type, the production function is given by

$$Y_j = \min[Z_j L, X] \quad (4)$$

where the first argument in production represents a "retail service" produced by the store, and the latter, X , is an intermediate good *purchased* by the store. A stylized description of the production process might consider X as a box of shirts, and Y_j as a rack full of shirts available for purchase at the store. Z_j is the efficiency of supplying the service, (slightly different than TFP, to be explained further below), and L is variable labor input. I assume that the modern technology is more efficient, i.e. $Z_M > Z_T$.

Assuming that stores are price takers in labor and intermediate goods markets, this technology gives rise to a constant marginal cost. Let the price of the intermediate be p_x , and let wage rate be w . Then the marginal cost for a producer of type j is given by

$$mc_j = p_x + \frac{w}{Z_j}. \quad (5)$$

Since $Z_M > Z_T$ it follows that the marginal cost of a modern store is lower than for a traditional one. In addition to the variable production costs, modern stores have a fixed cost $w\bar{L}$ required for operation, where \bar{L} represents overhead labor. The traditional store, in contrast, can be used at any desired scale. The motivation for this assumption comes from the idea that scale economies are crucial for the efficient operations of modern retailers, and that scale plays a relatively unimportant role for smaller stores.

4.3 Location and Price Competition

The two technologies are operated by profit-maximizing entrepreneurs who decide which type of technology to operate, if any. I assume unrestricted use of either technology, and hence all stores earn zero profits in equilibrium. As is standard in Salop-Hotelling models, I abstract from the choice of where to locate and focus on competition in pricing. I assume that competition among stores takes the form of a two-stage game. In the first stage, entering stores are placed evenly along the circumference of the circle. In the second stage, all stores choose prices and compete under Bertrand competition. More specifically, I assume that there is even spacing for any two modern stores, and even spacing for any two traditional stores. I make no assumption about spacing between traditional and modern stores, for reasons that will become clear shortly. The zero profit condition is that the number of stores of each type that enter in the first stage must yield zero profits for each store in stage two. While the assumption of even spacing might appear arbitrary, Vogel (2007) shows that when the choice of location is endogenized, producers with identical marginal costs optimally choose equidistant spacing.¹⁵

The results for traditional stores are easily characterized. Because they have no fixed operating costs, for zero profits it must be true that traditional stores choose a price p_T equal to their marginal cost mc_T . Furthermore, entry must occur for traditional stores until the space between any two traditional stores is zero. If, in contrast, there were positive spacing between any two traditional stores, then each could choose a price above marginal cost, still attracting a positive quantity of purchases, and thereby contradicting the zero-profit condition. So in equilibrium there must be a traditional store at each point along the circumference of the circle. The problem of a modern store is more involved to characterize. The number of modern stores, denoted N , adjusts such that in stage 2 each of the N stores earns zero profits. As is standard in this literature, I allow N to take on non-integer values. Because of the fixed cost, modern producers are always separated by some positive distance. From the point of view of households, there is always a traditional store "locally," or at a distance of zero, whereas the distance to the nearest modern store is positive. Before tackling the problem of the modern producer, it is convenient to present and solve the household problem.

¹⁵More generally, Vogel (2007) proves that producers choose to locate further away from competitors with lower marginal costs, and closer to higher-cost producers.

4.4 Household problem

Recall that households vary in two dimensions: where they are located, and their income level y . Given what we know about the production side of the model, it is convenient to represent each household's location by her distance away from the nearest modern store. Let this distance be x . Note that since all modern stores are identical, households on different parts of the circle that have the same distance x to a modern store and income y have the same problem, and therefore must make identical choices.

Figure 5 illustrates the households' shopping options. The edge of the circle is depicted as a straight line for convenience, and the red vertical line represents the household in question. The household is located between two modern stores, and for simplicity assume that each one sells for the same price p_M . Then the household can either travel a distance x to the nearest modern store and pay price p_M , or shop at the local traditional store (located exactly at distance 0 from the household) and pay price p_T . Modern stores are only viable when $p_M < p_T$, and so the household faces a price-distance tradeoff in its shopping decision.

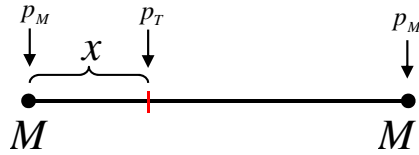


Figure 5: Household Shopping Choices.

Shopping time is modeled as a fixed time cost of traveling to the store. Let s_M and s_T be the shopping time at modern stores and traditional stores. Then s_M is given by

$$s_M \equiv \begin{cases} x \cdot \tau_A & \text{If } A = 1 \\ x \cdot \tau_B & \text{If } A = 0 \end{cases}$$

where τ_A and τ_B represent the time needed to traveling a unit of distance for auto owners and bus rides. I assume that $\tau_A < \tau_B$, meaning that that cars decrease transport costs. An analogous definition holds for s_T , although using the equilibrium condition that the distance to any traditional store is zero, it follows that $s_T = 0$. Note that the assumption of a fixed travel cost represents a departure from previous Salop-Hotelling models, which typically posit per-good transport costs. While this is quite

reasonable for many applications, in the present environment I see the biggest difference in time costs of shopping across sellers coming from travel time to the seller. Furthermore, a per-unit transport cost would imply that time spent shopping is directly proportional to total expenditure, whereas in reality richer households do not spend far more time shopping than poorer households. Thus I model the transport cost as being a fixed cost.

We can now formulate the problem of an arbitrary household located a distance x away from the closest modern store, with income y . Let c_M and c_T be consumption good purchases from the modern and traditional store, and let p_M and p_T be their respective prices. The household's problem is then

$$U = \max\{\log(c_M + c_T) + \log(1 - s_M - s_T) + \alpha A + c_s\} \quad (6)$$

subject to

$$p_M c_M + p_T c_T + p_s c_s + p_A A = y \quad (7)$$

$$s_M = x(A\tau_A + (1 - A)\tau_B). \quad (8)$$

where α captures the direct utility benefit of owning an auto. It is essential that the auto is modeled as a superior good, since a central part of the story is that richer households have higher car ownership rates. The retail good is modeled as a necessity because the single most important category of retail sales is food & beverages, with other necessary goods, such as clothing and basic household items, not far behind. It is unrealistic, however, to assume that all expenditure comes in the form of goods or services that must be purchased from retail stores. Thus I introduce c_s , which represents, for example, expenditure on vacation travel, higher education, or housing improvements.¹⁶

To summarize the household's problem, the household must decide whether or not to buy a car, where to shop, and how much of her income to spend on the necessity and the superior good. The former two choices are discrete, and hence the problem must be broken down into cases. Fortunately, under one simplifying assumption, the household's optimal behavior can be characterized by simple and intuitive cutoff rules. That assumption is that the value of an automobile be sufficiently high:

¹⁶The superior good c_s plays no important role in the theory, and is used only for more accurate calibration of the model in the next section.

Assumption 1 *The direct utility of owning an auto, α , satisfies*

$$\alpha \geq \log \left(\frac{p_s}{p_s - p_A} \right), \quad (9)$$

and superior and auto prices satisfy $p_s > p_A$.

This assumption posits that the utility of owning a car is high enough so that as a household becomes richer, they purchase a car before buying any of the superior good.¹⁷ The solution to the problem of an arbitrary household can now be characterized.

Proposition 1 *The optimal household transportation and shopping choices are characterized by the following cutoff rules. Shopping at the modern store is optimal when x satisfies*

$$x < \tilde{x}_i \equiv \frac{1 - p_M/p_T}{\tau_i} \quad (10)$$

where $i \in \{A, B\}$ indexes the optimal transportation choice. Purchasing an auto is optimal when x and y satisfy

$$y > y_A(x) \equiv \frac{p_A}{1 - \psi(x) \exp(-\alpha)} \quad (11)$$

where

$$\psi(x) \equiv \begin{cases} (1 - \tau_B x)/(1 - \tau_A x) & \text{if } x \leq \tilde{x}_B \\ (p_M/p_T)/(1 - \tau_A x) & \text{if } \tilde{x}_B < x \leq \tilde{x}_A \\ 1 & \text{if } x > \tilde{x}_A. \end{cases} \quad (12)$$

Notice that the distance cutoffs \tilde{x}_A and \tilde{x}_B do not depend on income: all households, no matter how rich, make the same shopping choice conditional on their transportation choice. Since the B -households have a higher time cost of shopping (i.e. $\tau_B > \tau_A$), it follows immediately that $\tilde{x}_B < \tilde{x}_A$: households with cars shop at modern stores more than households without them. The auto-purchase income cutoff $y_A(x)$ is non-monotonic in distance, and will be explained shortly. The final piece of the household problem is the choice of necessities or superior goods. One can show that purchasing the superior good is optimal if and only if $y > y_s \equiv p_s + p_A$. for households at any distance x , and only households with autos purchase the superior good. By the

¹⁷Without the assumption the solution is not quite as clean, although nothing of importance changes.

household's first order conditions, the optimal consumption choices are $c_M = \frac{p_s}{p_M}$ and $c_s = \frac{y - p_A}{p_s} - 1$.

Figure 6 illustrates the solution to the household's problem. The x -axis depicts the edge of the circle as a straight line for ease in illustration, and the y -axis represents household income. The modern store is depicted at the origin as point M . The cutoffs \tilde{x}_B and \tilde{x}_A show the distance cutoffs for B -households and A -households to shop at the modern store. The (darker) red shaded region represents the region in which households shop at M by car, and the (lighter) orange region is where households come to M by bus. Finally, the top line denotes y_s , the cutoff for purchasing the superior good.

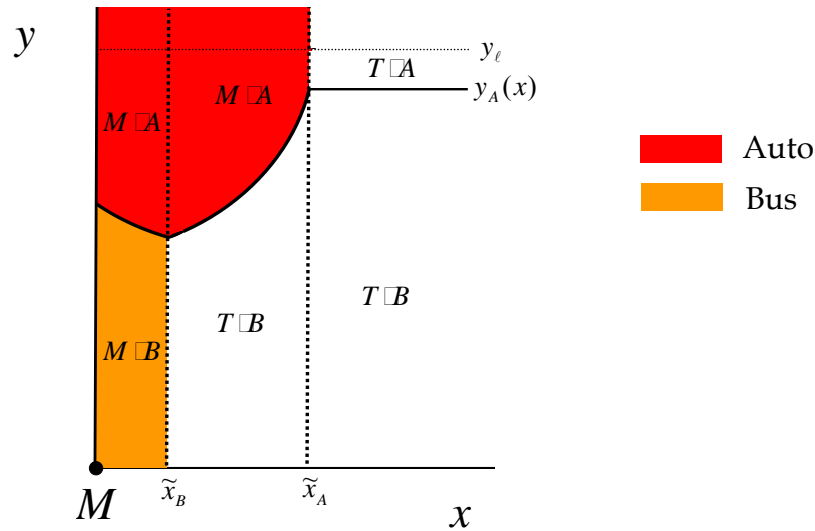


Figure 6: Solution to the Household Problem.

The nonmonotonicity in $y_A(x)$ can be explained as follows. For $x < \tilde{x}_B$, households are sufficiently close to the modern store that they will shop there whether or not they own an auto. Households further from the modern store stand to gain more than from the car, since it allows them to economize on costly transportation. Hence $y_A(x)$ is decreasing in this region. For households at a distance $\tilde{x}_B < x \leq \tilde{x}_A$, shopping at the modern store is optimal if and only if they buy a car. The cost of buying from the modern store increases with distance, but not the cost of buying from traditional store. Hence, in this distance range, households further from the modern store, are less likely to buy a car. Finally, beyond \tilde{x}_A distance is irrelevant for auto ownership, as no households this far from the modern store would shop there even with an auto.

4.5 Retail Store Profit Maximization Problem

Because of the fixed cost of operating a modern store, it is possible that variable profits are low enough to preclude modern stores from operating at all in equilibrium. I first consider a *single modern producer* that is deciding whether to operate. It solves:

$$\tilde{\Pi} = \max_{p_M} (p_M - mc_M) \tilde{Q}(p_M) - w\bar{L} \quad (13)$$

where $\tilde{Q}(p_M)$ is the quantity of goods sold given a price p_M by the single modern store, and $w\bar{L}$ is the fixed operating cost. The store solves the profit maximization problem and operates if $\tilde{\Pi} \geq 0$. The single-store quantity function $\tilde{Q}(p_M)$ is given by:

$$\tilde{Q}(p_M) = \int_0^{\tilde{x}_B} \int_0^{y_A(x)} \frac{y}{p_M} dG(y) dx + \int_0^{\tilde{x}_A} \left[\int_{y_A(x)}^{y_s} \frac{y - p_A}{p_M} dG(y) + \int_{y_s}^{\infty} \frac{p_s}{p_M} dG(y) \right] dx. \quad (14)$$

The first integral is the quantity of goods sold to *B*-households, and the second is the quantity sold to *A*-households. By lowering p_M the store can increase the size of its market by lowering its price in three dimensions, two of which can be seen clearly in Figure 6. It increases the market size width-wise, by raising \tilde{x}_A and \tilde{x}_B , hence bringing households from further away. It also lowers the threshold for buying a car, $y_A(x)$, which increases the red shaded region vertically. Not pictured, but still important, is that it increases the quantity that each household actually buys. This would be represented by the vertical height of the regions resting on the shaded regions in the figure.

In the case that the profits of a single modern producer, $\tilde{\Pi}$, is greater than zero, *multiple modern stores* must operate. In this case, each chooses a price given the prices of its two closest modern neighbors. Profits are given by:

$$\Pi(\hat{p}_M) = \max_{p_M} (p_M - mc_M) Q(p_M, \hat{p}_M) - w\bar{L} \quad (15)$$

where $Q(p_M, \hat{p}_M)$ is the quantity sold given a price p_M and neighbor prices \hat{p}_M . It turns out that $Q(p_M, \hat{p}_M)$ is defined exactly as $\tilde{Q}(p_M)$ only with a new shopping cutoff for *A*-households. That cutoff, which I call \tilde{x}_A again as an abuse of notation, represents the distance where *A*-households are indifferent between the closest two modern stores. In other words, competition among modern producers assures that no *A*-households are sufficiently far from a modern store so as not to shop there. Since this is an important property of the model, I state it formally.

Proposition 2 *If multiple modern stores operate, then all A-households and at least some of the B-households shop at modern stores.*

The intuition for this result is as follows. If multiple modern stores enter, it must be true that a single modern store that operates would earn positive profits. But if multiple modern stores operated and did not compete amongst each other for the furthest car-owning households, each store would price exactly as a single modern store operating in isolation, thereby (counterfactually) earning positive profits.

We know from Proposition 2 that \tilde{x}_A becomes the location where A-households are indifferent between the two closest modern stores. One can show that \tilde{x}_A is now given by:

$$\tilde{x}_A \equiv \frac{\hat{p}_M/p_M - 1 + \tau_A(1/N)}{\tau_A(1 + \hat{p}_M/p_M)} \quad (16)$$

where N is the number of modern stores on the circle, and hence $1/N$ is the arc length between any two such stores. The problem of each individual modern is given by (15), with \tilde{x}_A defined as in (16).

4.6 Equilibrium

An equilibrium in this economy is defined as follows:

Definition 1 *An equilibrium consists of prices p_M and p_T , a measure of modern stores N , and household decision rules $y_A(x)$, y_B , \tilde{x}_A , and \tilde{x}_B such that*

1. *Traditional stores set a price of $p_T = mc_T$*
2. *Modern stores choose price p_M taking as given p_M from other modern stores.*
3. *Modern stores earn zero profits.*
4. *Given prices, the household decision rules solve the household problem for each (x, y) .*
5. *Markets for the consumption goods c_M and c_T clear.*

4.7 Modern Employment Share and Sector Productivity

A nice property of this framework is that productivity in the model is determined by a simple linear combination of productivity for the modern and traditional producers, where the weight on modern productivity is given by the share of workers employed at modern producers. It is useful to define this share formally.

Definition 2 *Let μ be the share of employment at modern stores:*

$$\mu \equiv \frac{L_M + \bar{L}}{L_T + L_M + \bar{L}}. \quad (17)$$

Since labor is the only input to production, productivity for each store type is measured as a simple ratio of gross output to inputs. Specifically, I define labor productivity as $LP_M = Y_M / (L_M + \bar{L})$ and $LP_T = Y_T / L_T$. With these definitions in hand, we can define sector labor productivity¹⁸ to be

$$LP = \frac{Y_M + Y_T}{L_M + \bar{L} + L_T} = \mu LP_M + (1 - \mu) LP_T. \quad (18)$$

Since productivity in the sector as a whole is driven by μ , it is worth characterizing which parameters of the model raise or lower μ .

4.8 Comparative Statics for the Modern Employment Share

In this section I present the main qualitative results of the paper regarding μ , the share of labor inputs employed at modern stores. These also serve to motivate the quantitative section to follow. I first state the results formally, and then discuss the intuition and relevance behind each one. The main result is that the modern share is increasing in income.

Proposition 3 *Let μ_1 and μ_2 be the modern employment shares in equilibrium under income distributions $G_1(y)$ and $G_2(y)$, where $G_1(y) > G_2(y) \forall y$. Then $\mu_1 > \mu_2$.*

There are two reasons for this effect. First, higher income means that each household spends more. Second, a higher fraction of households purchase cars, which

¹⁸Labor productivity in this model corresponds to TFP. The term "labor productivity" seems more appropriate than "TFP" though since labor is the only factor of production.

brings household to the modern store from a further distance. Both effects increase the quantity sold and profits at a given modern store, leading to more entry of modern stores.

Proposition 4 *The modern employment share μ is decreasing in the auto price p_A , and transport costs τ_A .*

Increases in either p_A and τ_A reduce the market size for modern stores. For example for the car prices p_A comparative static, assume we are in equilibrium with N modern producers. Increases in auto prices serve to decrease the market for each modern firm by increasing the car-buying threshold $y_A(x)$ and hence reducing the number of households with cars. This reduces the quantity sold $Q(p_M)$ for any price, and leads to negative profits for each modern firm. The result is a lower N in the new equilibrium, and hence a lower μ . Transport costs reduce not only the car-buying threshold, but the distance cutoffs \tilde{x}_A and \tilde{x}_B for buying at modern stores. This also reduces market size, and hence the modern share and productivity. Higher fixed costs directly reduce modern profits, which again leads to a lower μ .

5 Parameterization

In this section I parameterize the model for two purposes. First to assess the model's ability to match cross-country differences in productivity in the retail sector, and second, to assess the impacts of policies in the developing that reduce the size of the market for large stores and retail productivity.

5.1 Matching A Representative Developing Country

I parameterize the model to match a representative developing country with per-capita income around the level of Turkey, Thailand, Poland, Mexico and Brazil, the developing countries studied in the empirical section of the paper. This set of countries has per-capita income around one fourth of the U.S. level. Because Mexican census data is readily available and generally of high quality, I set the income distribution $G(y)$ in the model using the 2000 Mexican Census. Specifically, I approximate the cdf of the Mexican income distribution using 20 equally spaced income possibilities between the 5th and 95th percentiles of the income distribution, filling in the

probability of each income realization according to its empirical counterpart in the Mexican census data.

Of the remaining parameters to be calibrated, two of the most important are the productivities in the two store types. I normalize LP_T to be 1, and set LP_M to be 3.5, which matches the relative TFP in modern to traditional stores that I calculated in Figure 3. The relative productivity in the two technology types sets the extent of productivity gains possible from the quantitative experiments, as productivity gains come from labor reallocation from traditional to modern producers. Also central is the annual cost of an auto, p_A , which should capture all the costs of owning a car, not just the purchase price. I set $p_A = \$1916$, which represents (in decreasing importance) the annualized purchase price of a car in Mexico, yearly gasoline costs, taxes & registration, insurance, and repairs.

In addition, I impose the following conditions on the model. First, I set the modern employment share μ to be 0.19, which is the share I measure from the Mexican Census of Commerce. Also based on this source, I take the percent retail margins in traditional stores to be 55%. Next, I choose the car ownership rate to be 32% to match the fraction of households reporting one or more cars in the 2000 Mexican Census of Households. For relative prices, Basker (2005) provides evidence that the price of the modern store (Wal-Mart in her data) is in the ballpark of 78% of what it is at the traditional store. This suggests setting p_M/p_T to 0.78. This is consistent with data on prices of modern and traditional stores cited by the McKinsey studies for Poland, which report prices 20% to 30% lower in modern stores than traditional ones.

I set average shopping time to be 1 hour per day, which is the average reported time spent "shopping for goods and services" in the American Time Use Survey (ATUS). In future work I will incorporate more time use data and relative price data from developing countries if possible. Finally, I set the total household expenditure share on necessities ($c_M + c_T$) to be 77%, which is equal to Mexican retail sales as a fraction of total Mexican consumption expenditure. The following table summarizes the choice of parameters.

5.2 Market Size and Cross-Country Retail Productivity Differences

As a test of the quantitative importance of the market size theory, I re-solve the model under the U.S. income level, keeping transportation and store productivity parameters the same. The goal of the test is to see whether with the U.S.'s high level of

	CONDITION	PARAMETER	REASON
1	$LP_T = 1$	Z_T	Normalization
2	$LP_M/LP_T = 3.5$	Z_M	Author's TFP calculations
3	Car ownership rate = 0.32	α	2000 Census, Brazil & Mexico
4	A-HH shopping time = 1 hrs/day	τ_A	American Time Use Survey (ATUS)
5	$\mu = 0.19$	τ_B	Modern employment share in Mexican data
6	Expenditure share on $c_M + c_T = 77\%$	p_s	Consumer Expenditure Survey
7	Relative Prices $p_M/p_T = 0.78$	\bar{L}	Basker (2005), other sources
8	Traditional Margins $(p_T - p_x)/p_x = 0.55$	p_x	Census of Commerce, Brazil & Mexico

income, the model predicts extensive use of the modern store as in the U.S. data. As the model is stylized, I view this experiment as suggestive of the importance of market size, rather than providing any definitive answers.

The experiment is as follows. I multiply each income realization in the distribution $G(y)$ by four to simulate moving from Mexico's income distribution to the US's income distribution, which is four times as high in PPP-adjusted terms. I also multiply the wage rate w and raw-good price \bar{p} by four, to capture the increased cost of hiring inputs in a country with higher income. These increase both the marginal costs for both stores and the fixed cost of the modern store.

MOMENT	BASELINE	INCOME X 4	U.S. DATA
Modern share μ	0.19	0.61	0.75
Car ownership rate	0.32	0.76	0.89
$c_M + c_T$ expenditure share	0.77	0.42	0.35 - 0.40
p_M/p_T	0.78	0.72	0.70 - 0.80

Table 2: Hypothetical Mexican Modern Share under U.S. Income Level

The results of the experiment are shown in Table 2. Under the U.S. income level, the model predicts a modern share $\mu = 0.61$, up from the original value of $\mu = 0.19$. Given that the U.S. modern share in the data is 0.75, the model's predictions constitute three quarters of the format composition differences with the U.S. The bottom three lines of the table display other key moments predicted by the model and their empirical counterpart in the U.S. The model under-predicts car ownership rates, with a 76% ownership level in the model compared to an 89% rate in the U.S. data. Presumably, lower transportation costs and lower car prices in the U.S. (but not in the model) could account for a large fraction of this gap. Finally, retail expenditure shares and relative prices of modern and traditional stores are in quite comparable in the model and U.S. data.

As argued in Section 2, composition differences account for roughly 70% of retail productivity differences. Thus the model can account for around 50% – 52% to be exact – of productivity differences in retail. This finding suggests that income differences across countries may be a major factor in explaining retail productivity levels. While this may be viewed as success for the market-size theory, it does not offer much guidance in terms of policy, since raising income levels directly is not a viable policy option. In the next section I explore TFP policies that work through the other major determinate of market size, namely transportation costs.

6 Policy Experiments

In this section I use the parameterized model to evaluate the effects of two types of policy changes on productivity in the retail sector.

6.1 Tax Evasion by Small Producers

When it comes to avoiding taxes and labor regulations, small retail stores have a clear advantage over larger stores, since tax authorities will be less inclined to inquire into missing tax payments for smaller establishments. In poor countries, where tax enforcement is frequently lax, small stores gain a cost advantage over larger stores by evading taxes and costly labor laws. De Soto (1989) emphasizes the ease in evading taxes for smaller producers, and the ease of operating informally more generally. The McKinsey studies conjecture that tax evasion by smaller stores is a major reason that modern stores operate so infrequently.

TRADITIONAL PRICE INCREASE	P_M/P_T	MODERN EMPLOYMENT SHARE	PRODUCTIVITY GAINS
0%	0.78	0.19	-
+5%	0.72	0.21	+1.3%
+10%	0.70	0.23	+3.5%
+15%	0.67	0.25	+9.7%
+20%	0.64	0.27	+11.7%

Table 3: Experiment 1 – Crack down on Tax Evasion

In this experiment I simulate a crack down on tax evasion by decreasing Z_T , the efficiency of production for the traditional store, which amounts to an increase in the price at traditional stores. I consider price increases of between 5% and 20%, which is consistent with McKinsey estimates of the price gains from avoiding taxes. The results are presented in Table 3. As the price in traditional stores increases, the model predicts a rise in the share of modern employment from 19% up to 27%, leading to TFP gains of between 1.3% and 11.7%. The results suggest that tax evasion is indeed an important factor in explaining retail productivity differences.

6.2 Distortions in the Market for Cars

There are numerous well-known distortions in the market for cars, in particular imported cars. Many developing countries have tariffs, taxes, or other fees on new cars which greatly increase the cost of new car purchases. Other trade frictions, such as Voluntary Export Restraints, serve to raise car prices as well. For example, Berry, Levinsohn and Pakes (1999) argue that Japanese prices were increased by around 10% to 25% in the U.S. because of Voluntary Export Restraints on cars from Japan.¹⁹

One perhaps lesser-known policy that a large number of developing countries share is restrictions on the imports of *used* cars.²⁰ These range from outright bans, to prohibitive tariffs, to restrictions on the age of the used vehicle that can be imported. Pelletiere and Reinert (2002) document the extent of restrictions in a large number of developed and developing countries, and find that used car restrictions are widespread and often severe. In 19 of the developing countries studied there are complete prohibitions of used-car imports. In another 27 countries there were other "substantial restrictions" of various kinds.²¹

My model provides a reason to believe used-car import bans are important for understanding low TFP in retailing in countries in which the bans are present. By

¹⁹Other studies for different industries have found evidence of substantially elevated domestic prices for goods in protected industries. Luzzo and Greenstein (1995) document that in the (heavily protected) Brazil personal computer industry, domestic PC prices were 70% - 100% higher than comparable PC's abroad.

²⁰Sen (1962) was perhaps the first to recognize the large potential for importing used machines into poorer nations, where labor-intensive maintenance and repair costs are much lower due to lower relative wages.

²¹As of 1999, there were complete bans on used-car imports in Argentina, Algeria, Brazil, Chile, China, Columbia, Ecuador, Egypt, India, Indonesia, Mexico, Pakistan, Paraguay, Philippines, South Korea, Thailand, Turkey, Uruguay, and Vietnam.

banning or restricting used car imports, policy makers are shutting off a potentially huge supply of cheap automobiles, which might be particularly attractive in areas where incomes are low and subsistence consumption levels preclude the purchase of an expensive new car. My model shows that cars are a complement to the high-productivity technology in retailing, and other segments of the economy where transportation costs between producers and consumers are likely to be important. By shutting off access to these complementary goods, these policies serve to reduce adoption of the efficient technologies, and reduce TFP in this segment of the economy.

Evidence on the effects of removing bans on imports of used machines is scarce. Fortunately, for the automobile industry there is excellent evidence for one particular case, which is Cyprus in the 1990s. Clerides (2005) documents that Cyprus greatly repealed their limitations on the imports of used cars in 1993 leading to massive increases in imports of used cars from Japan.²² As this policy occurred largely independently of other policies, Clerides argues that the policy change constitutes a fairly clear natural experiment. He finds that after the restrictions were repealed, prices of the imported cars were just 33% to 50% as high as new cars of the same make and model sold, and substantially lower than existing used car prices as well. Furthermore, the overall car market expanded greatly in Cyprus after the bans were repealed. While the bans were still in place, just 7% of all first-time car registrations in Cyprus were imported used cars. After the ban was repealed, this figure skyrocketed to 60% of all first-time registrations.

I collect and analyze supermarket opening data from Cyprus around the time of the car-market liberalization, and find strong evidence that modern stores became more prevalent over this period as well. Figure 7 shows the number of used cars sold in Cyprus over this period and the number of supermarket stores at the largest 5 chains in Cyprus. A few years after 1993 the drastic increase in sales of used cars is clearly visible. The figure also shows that the largest Cypriot supermarket chains expanded over this period, roughly tripling the number of stores. While there are likely to be other forces at work in the expansion of supermarkets over this period, such as rising overall income, it is plausible that the rise in cars were a major factor in the rise of supermarkets. At the very least the Cyprus evidence provides evidence consistent with the predictions of the model.

²²Clerides and Hadjiyiannis (2007) argue that differences in quality standards for used goods across countries are a major catalyst for international trade in used goods. In the case of cars, they provide evidence that Japanese used-car quality standards are substantially more stringent than in most other countries, thus providing added incentive for Japanese households to sell their used cars abroad.

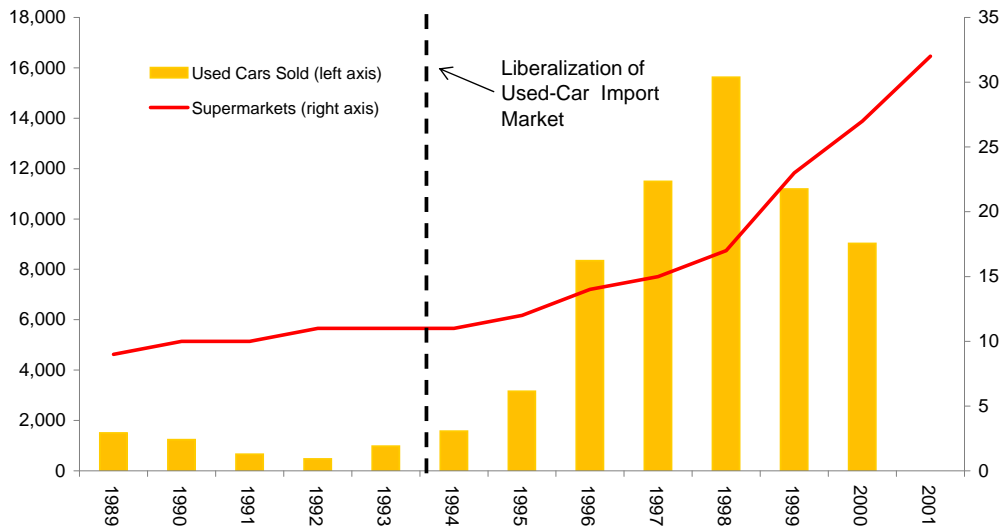


Figure 7: Cyprus Used Car Sales and Supermarkets of Five Largest Chains (Source for Car data: Clerides (2005).)

6.2.1 The Experiment: Removing Distortions on Car Markets

In this section I attempt to gauge the quantitative impacts of distortions in the car market on TFP in retail. I do so by calculating the equilibrium of the model under various assumptions about how much prices would fall after the distortions to the market for cars were removed. The primary object of interest from the experiment is the gain in TFP associated with the policy change. In the experiment I consider show a wider range of price drops, from 10% to 40%, broadly consistent with the auto price drops in Cyprus.

The results of the experiment are presented in Table 4. As car prices fall up to 40%, which can be thought of as an upper bound on the effects of car market liberalization, the modern share rises from 19% to 41% resulting in large TFP gains of over 30%. For more modest price drops, TFP gains are also substantial. I conclude that plausible decreases in auto prices can lead to sizeable increases in retail TFP on the order of 15-30%.

One key prediction of the experiment is the extent to which car ownership rates rise when prices fall. The model predicts that a 40% price drop leads to an increase in car ownership from 32% to 51%. The implied elasticity of the model is broadly consistent with econometric evidence on the auto market. McCarthy (1996) surveys estimates of the market price elasticity of demand for cars and finds a range of -0.6 to -1.2. The

AUTO PRICE REDUCTION	AUTO OWNERSHIP RATE	MODERN EMPLOYMENT SHARE	PRODUCTIVITY GAINS
0%	0.32	0.19	-
-10%	0.35	0.23	+4.4%
-20%	0.39	0.28	+15.5%
-30%	0.44	0.34	+25.6%
-40%	0.50	0.41	+30.3%

Table 4: Experiment 2 – Removal of Distortions in Car Markets

model’s implied elasticity is a bit higher, at around 1.8. Of course market elasticities of demand are likely to depend on the income level of the country in question. One can imagine a higher elasticity (in absolute value) for poorer countries assuming that a large number of households have income just below the cutoff required to buy a car. On the other hand, because of subsistence consumption requirements, a lower elasticity for poorer countries is possible as well. In any event, the elasticities that the model produces are broadly consistent with the range previously found.

How realistic is it that car ownership rates would be above 50% in Latin America given their low income levels? To shed light on this question, I point out that the U.S. real income per capita in the 1950s was on par with Latin America’s today. In the U.S. in the 1950s around half of households own cars. While other important differences differentiate Mexico today and the U.S. fifty years ago, such as infrastructure and geography, a 50% car ownership rate in Latin America today is certainly not implausible.

7 Alternative Hypotheses

This paper has advanced the view that market size is the limiting factor in explaining the limited use of modern retail formats in less developed countries. In this section I discuss other alternative explanations for the facts at hand.

Other Complementary Household Goods

Automobiles are just one potential household good that might complement mod-

ern stores. Other important examples are storage space at home and refrigerators. Storage space is crucial when households plan to buy in bulk and economize on the number of shopping trips. On the other hand, having a lot of storage space is similar to an automobile in that it is a superior good, and both autos and storage space serve as complements to modern stores. I therefore consider the storage-space story as being quite similar to the auto story in spirit, although the present analysis does not model storage & bulk purchases formally.

The advent and dispersion of refrigerators is also likely to have increased the diffusion of modern stores in the United States in the latter half of the 20th century. Fridges allow for larger but less frequent shopping trips, which might increase the appeal of lower-priced modern retail stores. In poor countries, fridge ownership rates, like car ownership rates, are lower than in the U.S. Yet unlike cars, they are much closer to U.S. ownership levels. According to Census micro data from the 2000, fridge ownership rates are around 70% of households in Mexico and 83% of households in Brazil. Given that fridges are so widely owned, the quantitative importance of fridges is likely to be small in explaining the limited use of modern formats. In terms of policy, there is also likely to be less scope for improvement here, as markets for fridges do not appear to be as distorted as markets for cars.

Factor Price Differences

Another potential explanation for the retail compositional differences between developing and richer countries is differences in factor prices. In particular, relative wages are lower in developing countries, and so one would expect relatively more use of labor-intensive technologies, in this case traditional retail stores. One major challenge to this hypothesis is the stark differences in use of modern retail stores even *within* developing countries, as documented in Section 2, even in the face of relatively minor wage differentials across districts. Furthermore, the biggest differences in factor prices across districts are in land prices, with substantial higher land prices in richer districts. The factor price theory would then predict that there would be much more intensive use of modern stores in districts where land is the cheapest, namely rural areas, which is strongly counterfactual.

Transportation infrastructure

One clear difference between the US and the developing world is the strong system of highways and local roads in the US. Most poor countries have much less in the

way of transportation infrastructure. Few or poor quality roads is likely not only to increase the cost of operation for a large retailer, but to decrease the desirability of owning a car for households. Both effects seem likely plausible limiting factors for large-scale producers.

Economies of Density

As Holmes (2008) demonstrates, economies of density have been an important factor in the rise of Wal-Mart in the U.S. The ability to locate stores in close proximity to one another has allowed Wal-Mart to economize on shipping, advertising, personnel, and other costs. Unlike the U.S., though, this paper argues that Mexico and other developing countries have few geographic locations that can support such a large store. In this case retail chains in poor countries will be less able to utilize economies of density to decrease their overall costs. A retail chain operating in a developing country would be forced, unlike Wal-Mart in the U.S., to locate stores a great distance from one another, limiting the cost savings from density. Exploring this idea in more detail seems like a promising line of future research.

Restrictions on Large-Scale Stores

Guner, Ventura and Xu (2008) argue that the composition of large and small retail stores is often directly affected by government policy. They cite direct evidence that small retail stores are heavily favored by law in Japan. Retail establishments above a certain size threshold are taxed more heavily, leading to disproportionately many small retail stores. In the set of countries I study, however, such explicit policies are not present, and hence I treat the employment composition across store types to be induced by the market. According to the McKinsey studies, the types of size-dependent policies most directly relevant for retail are the (implicit) policies which allow small stores to successfully evade taxes and costly labor market regulations. Indeed, there is widespread evidence that small retailers operate informally much more frequently than larger stores, and more frequently than larger establishments more generally.

8 Conclusion

In this paper I shed new light on TFP differences across countries using disaggregated productivity data from the retail sector, which constitutes one-fifth of the private em-

ployment. I document that the bulk of retail productivity differences between rich and developing countries are due to differences in the composition of technologies employed, as opposed to less efficient use of particular technologies. Surprisingly, productivity in modern stores in poor countries is roughly as high as those in richer countries. My findings suggest that a theory of TFP differences, to explain at least the retail sector, should be a theory of why modern technologies in poor countries are used so infrequently.

I provide one such theory, which is that market size limits the use of large-scale, high productivity retail technologies. As supporting evidence, I show that within developing countries, most of the modern retail stores are located in the largest markets where income and car ownership rates are high. I formalize the hypothesis in a spatial model of technology adoption in which market size drives the use of a high-productivity modern technology and less productive traditional technology. Market size is determined by income and transportation costs of households, who trade off price and distance in determining where to shop. Automobiles decrease household transport costs, and serve as complements to the modern technology. The idea that the demand side drives technology adoption contrasts with the majority of papers explaining TFP, which focus on distortions on the production side of the economy.

The paper provides novel policy implications for TFP. Policies that discourage households from acquiring durable goods can lower TFP when those durables are complements to modern technologies. For retailing, policies that distort the market for cars, which are widespread in poor countries, lead to lower diffusion of modern stores, and lower TFP. Policies that favor small-scale producers, even indirectly, can lead to lower TFP if small-scale producers are less efficient. Again, this is relevant in the retail sector where smaller traditional stores can more easily evade taxes than large-scale modern retailers. I parameterize the model and compute the effects of these two policies, and find that both improved tax enforcement efforts and liberalized car markets can lead to sizeable TFP gains in the retail sector.

The paper suggests several avenues for future research. First, it would be valuable to gauge the importance of demands-side factors in explaining TFP differences more broadly. Other non-tradeable service industries seem like promising avenues to explore, as there is reason to believe domestic market size plays an important role there in limited large-scale service producers. Second, the role of household durable goods as complements to new technologies warrants further exploration, as other examples are likely to be important. For example widespread personal computer ownership is

almost certainly a driving factor in the dramatic rise of internet services in the U.S. in recent years. It seems plausible that the lack of similar rises in internet-related industry in poorer countries is closely related to limited household ownership of computers. Finally, the role of transportation costs in the diffusion of new technologies seems worthy of further exploration, as large differences in transportation costs exist across countries and have a first-order effect on most transactions between consumers and producers.

Finally, the paper raises questions about whether TFP is actually measured correctly. Conceptually, TFP should reflect the amount of output able to be produced using some fixed amount of productive inputs. In his analysis of the retail sector, Oi (1992) argues that households themselves are inputs, and should be explicit arguments in the production function. The present paper highlights the importance of household durable goods, such as cars, in retail production. Not counting these inputs leads to overestimates of TFP, particularly in the segments of the economy where household play an important role in facilitating market transactions. Future research could measure the importance of household inputs in explaining measured TFP differences more broadly.

A Data Appendix

A.1 Alternative PPP Exchange Rates

In order to compare retail productivity across countries, it is necessary to deflate output using a PPP exchange rate. The choice of a PPP exchange rate is crucial, as differences in cross-country price levels can lead to substantial over or underestimation of productivity levels. In this analysis I consider two alternative deflation methods, namely *single deflation* and *double deflation*. Single deflation, which is used exclusively in the main analysis of the paper, refers to dividing value added by an exchange rate for retail output, while double deflation deflates sales by an exchange rate for output prices, deflates purchased inputs by an exchange rate for input prices, and sets the difference to be the measure of retail output. Double deflation is preferable in theory since it provides a more direct measure of the price of the service being provided, although is considerably harder to carry out in practice due to limited availability of input price measures across countries.

Two countries provide sufficient data to construct double-deflated PPP exchange rates, namely Brazil and Mexico. For Brazil I use data from Nanno Mulder (1994) and for Mexico I build on the price measures of Bart van Ark and Angus Maddison (1994). These studies use micro data on goods prices from 1975 to construct "unit value ratios," or relative price measures, for purchased retail goods and goods sold. They end up with PPP exchange rates for sales and purchases which allows them to double deflate retail value added in 1975 and compare Mexico and Brazil retail productivity with the US in 1975. I use their measures to construct PPPs in 2002 using the producer price indices and consumer price indices for each country from 1975 to 2002. More precisely, let $PPPP_t^{i,j}$ and $PPPS_t^{i,j}$ be the PPP exchange rates for purchases and sales in year t between countries i and j , and let $\Pi_{PPI,t,\tau}^i$ and $\Pi_{CPI,t,\tau}^i$ be cumulative inflation in country i from time t to time τ in producer and consumer prices respectively. Then I construct 2002 PPPs for country j as

$$PPPP_{02}^{j,US} = PPPP_{75}^{j,US,P} \frac{\Pi_{PPI,75,02}^j}{\Pi_{PPI,75,02}^j} \quad (19)$$

and

$$PPPS_{02}^{j,US} = PPPS_{75}^{j,US,P} \frac{\Pi_{CPI,75,02}^j}{\Pi_{CPI,75,02}^{US}}. \quad (20)$$

The PPI and CPI used for Brazil are the *Índice de Preços por Atacado* (IPA), an index of wholesale prices, and the *Índice de Preços ao Consumidor* (IPC), an index of consumer prices. Both are publicly available from the Central Bank of Brazil. For Mexico, I used the *Índice Nacional de Precios Productor* (INPP) and *Índice Nacional de Precios al Consumidor* (INPC), both available from the Banco de México.

		VA/L (US = 100)			TFP (US = 100)			Employment Shares	
		Retail Sector	Modern	Trad.	Retail Sector	Modern	Trad.	Modern	Trad.
Mexico (1998)	<i>Deflation</i> Single	25.1	45.8	20.3	47.5	83.7	38.5	0.19	0.81
	Double	33.3	62.6	26.4	57.1	102.4	46.9		
Brazil (2002)	<i>Deflation</i> Single	24.1	46.4	15.4	-	-	-	0.28	0.72
	Double	25.8	53.6	15.0	-	-	-		
Thailand (2001)	<i>Deflation</i> Single	37.2	69.4	27.0	52.5	94.2	38.7	0.24	0.76
	Double	-	-	-	-	-	-		

Table 5: Relative TFP under Single and Double Deflation.

Table 5 presents the TFP calculations under the two deflation methods. In both cases, both value added per worker (VA/L) and TFP are higher under double deflation, yet in the same generally ballpark as under single deflation. Due to the relatively crude nature of the double deflation, in particular the updating of the unit value ratios since 1975, the results should be taken as suggestive that the choice of deflation method does not substantially change the main results. In the absence of more recent unit value ratios, more precise productivity calculations using double deflation will remain limited.

A.2 Measuring Labor Shares

If all workers were paid workers, the labor shares at modern and traditional producers could be pinned down from the ratio of the wage bill to value added. However, many workers in retail trade are self-employed, and receive no wages directly. This is especially true in the smallest establishments. For example, in the Mexican census

data, the wage bill in establishments with less than 20 workers is only 14% of value added, which is an implausibly low share for labor in production. So measuring the labor shares directly from the data is not a viable option.

I therefore measure $\gamma_{i,M}$ and $\gamma_{i,T}$ in the following way. For $\gamma_{i,M}$, I take the wage bill over value added in the largest establishments in the data, namely 250+ employees, in which unpaid employees are likely to play an unimportant role. For Mexico, where I feel the wage bill data is more reliable, I find $\gamma_{i,M} = 0.50$. To compute $\gamma_{i,T}$, I make the assumption that both modern and traditional establishments are price takers in factor markets, and face the same wage rate to rental rate ratio. The firms' first order conditions then imply that:

$$\frac{w}{r} = \frac{\gamma_{i,M}}{1 - \gamma_{i,M}} \frac{K_{i,M}}{L_{i,M}} = \frac{\gamma_{i,T}}{1 - \gamma_{i,T}} \frac{K_{i,T}}{L_{i,T}} \quad (21)$$

for the given wage rate w and rental rate r . Then, using the modern labor share of 0.50 and the relative capital-labor ratios taken from retail census data, we can pin down the traditional labor share to be $\gamma_{i,T} = 0.71$.

A.3 Census Micro Data & Geographic Data

For a number of calculations, including car ownership rates, I make use of Census micro data from 2000 for the U.S., Brazil and Mexico. I obtain this data via the Minnesota Population Center's International Public-Use Micro Data (I-IPUMS). I supplement this data with additional data from the U.S. Census Bureau, the Mexican *Instituto Nacional de Estadística, Geografía e Informática* (INEGI), and the Brazilian *Instituto Brasileiro de Geografia e Estatística* (IBGE). These statistical agencies are considered the premier sources of demographic and economic data in their respective countries. All data is publicly available at www.census.gov, www.inegi.gob.mx/inegi/default.aspx and www.ibge.gov.br/home/. My data on average U.S. household income and population density by county comes from the 2000 Census *Small Area Income and Poverty Estimates*.

The main official source of data on the retail sector in Mexico is the *Censo Comercial* which has been conducted roughly every 5 years from 1956 to 2004. The data is available from INEGI. I make use of county-level data from 1999, which is available for purchase from INEGI.

B Proofs and Derivations

B.1 Proof of Proposition 1

Let $i \in \{A, B\}$ denote the household transportation choice. Assume for simplicity that the household does not spend any income on superior goods, although an identical solution obtains in that case. The household is indifferent between shopping at the modern and traditional stores when

$$\log\left(\frac{y - p_A}{p_M}\right) + \log(1 - \tau_i x) = \log\left(\frac{y - p_A}{p_T}\right)$$

which, solving for x , gives a distance cutoff

$$\tilde{x}_i = \frac{1 - p_M/p_T}{\tau_i}.$$

To solve for $y_A(x)$, consider first households at a distance less than \tilde{x}_B to the modern store, who will shop at the modern store whether or not they have a car. They are indifferent between buying an auto or not when

$$y = p_A \left[1 - \exp(-\alpha) \left(\frac{1 - \tau_A x}{1 - \tau_B x} \right) \right]^{-1}.$$

Households at a distance x between \tilde{x}_B and \tilde{x}_A shop at the modern store if and only if they have a car. They are indifferent when

$$y = p_A \left[1 - \exp(-\alpha) (1 - \tau_A x)^{-1} \left(\frac{p_M}{p_T} \right) \right]^{-1}.$$

Households at a distance $x > \tilde{x}_A$ shop at the traditional store independent of their transportation choice, and are indifferent between buying a car or not when

$$y = \frac{p_A}{1 - \exp(-\alpha)}.$$

The $\psi(x)$ function can be recovered from these three expressions. ■

B.2 Proof of Proposition 2

Assume not. That is, assume $N > 1$ and let (x^*, y^*) denote the household that buys a car but does not shop at some modern store. Then it must be true that $x^* > \tilde{x}_A = \frac{1-p_M/p_T}{\tau_A}$ and any household at distance \tilde{x}_A is indifferent between the closest modern store and local traditional store. In this case each modern store has the problem (13) of a single modern store, and hence earns profits $\Pi(\hat{p}_M)$ equal to $\tilde{\Pi}$. But if $N > 1$, it must be the case that $\tilde{\Pi} > 0$, which contradicts the zero-profit condition. Thus, there is no such A-household (x^*, y^*) that does not shop at a modern store. ■

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