Superstores or Mom and Pops?
Market Size, Technology Adoption and TFP Differences

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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 explains around 60% of the difference in retail format mix between the U.S. and the developing world, and around 50% of retail productivity differences. 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.

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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 resource misallocation 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 levels.

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 around 80% 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...

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 & Texeira, 2007; Barseghyan, 2006) or an insufficient supply of skilled labor (Acemoglu and Zilibotti, 2001; Caselli and Coleman, 2002; Moscoso Boedo, 2007).
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 (Instituto Nacional de Geografía e Estadística, 2000), and in Argentina, Burstein et al (2003) report an employment share of 21% for retail and wholesale trade in 1997.
recoup the fixed costs of their large-scale operations. In developing countries, relatively 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.

I parameterize the model and use it to quantify the role of market size in explaining TFP differences in retailing. I find that the model can explain around 60% of the differences in the mix of retail formats used in the U.S and a developing country with one quarter of the U.S. income level, such as most Latin American nations. Since format mix differences account for 80% of retail productivity differences, my model can explain around 50% of those productivity differences. I conclude that market size is 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 25%.

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 (2004) 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 Roger-son (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 (2006) use plant-level data from India and China to calculate the TFP gains from a hypothetical reduction in the dis-persion 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.4

My paper also complements the recent literature on the rise of modern retail stores in the U.S. Basker (2006) and Holmes (2006) are two prominent examples that explore the rise of Wal-Mart, and Jarmin, Klimek and Miranda (2005) 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.5 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 increase in 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 (2006, 2007) 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 technologies and in driving TFP differences appears new to this literature.

4Bresnahan and Reiss (1991) provide perhaps the first paper examining the role of market size on entry in the presence of fixed costs.

5The 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 suggest that the role is more pronounced in retailing.
The rest of this paper is organized as follows. In Section 2, I document that differences in the composition of retail formats used explains 80% of cross-country productivity differences in the retail sector. I develop a theory of the retail format composition in Section 3, using a spatial model of technology adoption. I parameterize the model in Section 4, and use it for policy experiments in Section 5. In Section 6 I discuss extensions of the model and several alternative explanations for the facts at hand, and in Section 7 I conclude.

2 Empirical Findings

2.1 Compositional Differences Explain Most of The Retail TFP Gap

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 most of the TFP gap in the retail sector. I begin the analysis with rich disaggregate labor productivity data for retailing that was collected as part of the McKinsey productivity studies. The studies 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 addition, I offer a detailed description of the studies I employ in the Data Appendix.

To construct labor productivity, output in the McKinsey studies is measured as value added, which is “the best simple measure of retailing output” (Baily & Solow, 2001). Labor input is 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 retailing, McKinsey computed labor productivity measures for two types of retailers: traditional and modern, which comprise 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 grocery stores. These stores are typically as-

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6See Baily (1993), Bosworth & Triplett (2004), or Yuskavage (2006) for detailed discussions of the alternative output measured used in retailing including the limitations of each measure.
sociated with limited less sophisticated distribution techniques and less division of labor.\(^7\)

Figure 1: Labor Productivity by Type of Retail Store.

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. 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 aggregated data, output per worker in the U.S. is higher than the developing countries by a factor of 4 or 5. 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.\(^8\) 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

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\(^7\) Indeed many traditional stores are run by a single entrepreneur.

\(^8\) McKinsey also conducted a similar analysis in four other developing countries that I’m aware of: Brazil, Mexico, Russia, and India. For Brazil, Mexico and Russia only the food retail sector was studied and McKinsey similar 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 policy that total restricts entry of foreign retailers, which would presumably be modern, and (2) forces all retailers to hire extra “un-needed” labor.
countries are roughly on par with the most productive in the US. One reason 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. 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.

So why is retail-sector output per worker 4 to 5 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 over three quarters of the labor inputs in the U.S., and less than 10% in the developing countries. 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

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9For example, the French retailer Carrefour has extensive operations in Poland, Turkey and Brazil, among other places, and is the leading retailer in Brazil. Similarly, Wal-Mart is the leading retail firm in Mexico and Central America.

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.
the developing world is largely explained by the low employment share of modern retailers in the developing countries.\textsuperscript{11}

As a concrete measure of the importance of composition effects, I re-compute productivity in the developing countries studied under the U.S.'s format composition, keeping productivity in the modern and traditional stores constant. Under this measure, retail-sector labor productivity would be 85\% of the U.S. level, up from 25\% in the data. This corresponds to closing 80\% of the productivity gap with the U.S.. In the next section, I show that labor productivity differences largely reflect TFP differences, and hence that composition effects drive the bulk of retail TFP differences across countries as well.

2.2 TFP is Much Higher in Modern Stores than Traditional Stores

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 retail technology. Moreover, there is good reason to believe that the modern technology uses non-labor inputs more intensively than their traditional counterparts. Computerized cash registers and scanners are prominent examples of capital equipment that are widely used in modern stores and not in traditional ones. Capital structures and land are also likely to be a more intensive component of the operations of a modern retailer. Since the object of interest in the paper is TFP differences across countries, not capital per worker differences, it is important to ascertain whether the higher labor productivity in modern stores reflects TFP differences, and to what extent.

In this section I address this question by constructing relative TFP measures between modern and traditional formats using my own independent evidence on capital and land per worker, capital shares, and percent gross margins in the two store types. I proceed in two ways. First, I use the McKinsey output per worker data in combination with my independent measures. Second, I compute relative TFP directly from the 2000 Economic Census of Wholesale and Retail Trade from Mexico and 2002 Census of Commerce from Brazil.

\textsuperscript{11}Guner, Ventura and Xu (2006) argue that the composition of large and small retail stores is often directly affected by government policy. For example in Japan, retail establishments above a certain size threshold area strongly restricted, 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 market-induced.
The most common TFP measures in the macroeconomics literature are backed out of a Cobb-Douglas production function. Following this literature, I posit the following retail production function for measurement purposes. Let \( j \in \{ M, T \} \) index the type of technology used (i.e. modern or traditional). Then output \( Y_j \) is given

\[
Y_j = \min[A_j L_j^{\gamma_j} K^{1-\gamma_j}, X]
\]

where \( X \) is a raw good purchased by the store, \( L \) is labor input, and \( K \) is interpreted broadly as inputs of capital equipment, capital structures, and land, \( A_j \) is TFP in technology \( j \), and \( \gamma_j \) is the labor share in technology \( j \). Under this specification, retailers combine the raw good \( X \) (say a box of cereal) with a retail service (placing the box on a shelf with other cereals, providing a shopping cart, and so forth), which the firm produces using capital and labor. Letting the prices of the raw good and final output be \( p_x \) and \( p_j \) for technology \( j \), value added is equal to \( VA_j = (p_j - p_x)Y_j \), which is simply revenue minus cost of raw inputs. The ratio of value added per worker in \( M \) and \( T \) producers is given by

\[
\frac{VA_M/L_M}{VA_T/L_T} = \frac{\mu_M A_M (K_M/L_M)^{1-\gamma_M}}{\mu_T A_T (K_T/L_T)^{1-\gamma_T}}
\]

where \( \mu_j = (p_j - p_x)/p_x \) is the percent gross margin of a store of type \( j \). Solving for the relative TFP yields

\[
\frac{A_M}{A_T} = \frac{\mu_T}{\mu_M} \frac{VA_M/L_M}{VA_T/L_T} \frac{(K_T/L_T)^{1-\gamma_T}}{(K_M/L_M)^{1-\gamma_M}}
\]  

(1)

To compute the TFP ratio from (1) we need estimates of the labor shares for each technology. Using disaggregated data on inputs, outputs and payments to labor from the 2000 Mexican Census of Commerce, I estimate the modern labor share to be \( \gamma_M = 0.50 \) and the traditional one to be \( \gamma_T = 0.71 \). Since these calculations are central to the measurement task at hand, I provide the details of the calculations in the data appendix. The lower labor share in modern stores is as expected, given the structure-intensive and land-intensive nature of their operations.

It turns out that when \( \gamma_M \neq \gamma_T \), the relative TFP is a function of the units in which capital is measured.\textsuperscript{12} Therefore I consider two relative TFP measures, based on two

\textsuperscript{12}Bernard and Jones (1996) make this point as well in their study of cross-country TFP by industry. This was not obvious to me when I first saw it, so I illustrate it in the Appendix for the reader’s
different normalizations for the capital-labor ratio. The first relative TFP measure normalizes $K_M/L_M$ to be 1, while the second normalizes $K_T/L_T$ to be 1. “TFP ratio 1” tells us how much higher output would be per worker in modern stores than traditional one if each were to use the capital-labor ratio of the modern technology. “TFP ratio 2” answers the same question only with each store using the capital-labor ratio of the traditional technology. These ratios provide an upper and lower bound on relative TFP.

The remaining three terms in ratio (1) are the ratio of margins, $\frac{\mu_T}{\mu_M}$, which I measure to be 1.2 from the Mexican Census of Commerce. The second is the ratio of value added per worker, $\frac{VAM/L_M}{VAT/L_T}$, which I take for each country from the McKinsey studies or economic censes, depending on the country. These range from 3 to 6, as can be seen in Figure 1. The third is the ratio of capital & land per worker in modern to traditional stores, which I measure to be 2.5 using the Mexican Census data. Since data for non-labor inputs per worker by type of establishment are scarce, I use the Mexican figure for all countries.

The relative TFP ratios are presented in the Table 1. Panel A contains the results when I use value added and employment data from the McKinsey studies, and Panel B for when I use data from the most recent Mexican and Brazilian Censes of Commerce. The main conceptual difference between Panel A and Panel B is the definition of a modern and traditional establishments. In Panel B, I proxy modern stores by establishments with 20 or more workers, and traditional by establishments with less than 20 workers. The main finding shown in the table is that TFP is substantially higher in modern stores. Modern TFP is around 3 to 4 times higher than traditional according to the McKinsey data, and around 2 to 3 times higher in the Census data. By either measure, modern stores have much higher measured TFP than traditional stores.

As a sense of how important composition effects are in the retail sector, the last column shows how much retail TFP would rise in each country if the country had the U.S. share of 79% of employment in modern stores, rather than their existing shares of around 10% or less. The TFP gains are huge, in the range of 100% to 250% according to the McKinsey data or 40% to 80% from the census data. This analysis convenience.

13The only other evidence I have seen on capital per worker by size-class of retailer is from Foster, Haltiwanger and Krizan (2006), who calculate that the largest retail stores have 1.5 times as much capital equipment per worker than the largest. Their calculation comes from the Annual Capital Expenditure Survey (ACES). Their figure is lower than mine since it only includes certain types of capital equipment, and not capital structures or land.

14A word is order about why the TFP calculations based on the McKinsey data yield such larger TFP
### Panel A: Relative TFP in Modern & Traditional Stores: McKinsey VA/L Data

<table>
<thead>
<tr>
<th>Country</th>
<th>Year</th>
<th>Relative TFP Ratio 1</th>
<th>Relative TFP Ratio 2</th>
<th>Relative VA/L</th>
<th>Modern Employment Share Ratio 1</th>
<th>TFP Gains Under US Modern Share Ratio 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brazil*</td>
<td>1995</td>
<td>4.3</td>
<td>3.5</td>
<td>4.6</td>
<td>0.07</td>
<td>191%</td>
</tr>
<tr>
<td>Mexico*</td>
<td>2001</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.09</td>
<td>-</td>
</tr>
<tr>
<td>Poland</td>
<td>1999</td>
<td>4.2</td>
<td>3.5</td>
<td>4.6</td>
<td>0.08</td>
<td>182%</td>
</tr>
<tr>
<td>Thailand</td>
<td>1999</td>
<td>7.6</td>
<td>6.2</td>
<td>8.2</td>
<td>0.10</td>
<td>274%</td>
</tr>
<tr>
<td>Turkey</td>
<td>2001</td>
<td>3.1</td>
<td>2.6</td>
<td>3.4</td>
<td>0.12</td>
<td>114%</td>
</tr>
<tr>
<td>Russia*</td>
<td>1996</td>
<td>3.1</td>
<td>2.6</td>
<td>3.4</td>
<td>0.01</td>
<td>162%</td>
</tr>
</tbody>
</table>

Average: 
- 4.5
- 3.7
- 4.8
- 0.08
154% 125%

| U.S.     | -    | 3.4                  | 2.8                  | 3.7           | 0.79                             | -                                        |

### Panel B: Relative TFP in Modern & Traditional Stores: Census VA/L Data

<table>
<thead>
<tr>
<th>Country</th>
<th>Year</th>
<th>Relative TFP Ratio 1</th>
<th>Relative TFP Ratio 2</th>
<th>Relative VA/L</th>
<th>Modern Employment Share</th>
<th>TFP Gains Under US Modern Share</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brazil</td>
<td>2002</td>
<td>2.8</td>
<td>2.3</td>
<td>3.0</td>
<td>-</td>
<td>**79%</td>
</tr>
<tr>
<td>Mexico</td>
<td>2000</td>
<td>2.1</td>
<td>1.7</td>
<td>2.3</td>
<td>0.19</td>
<td>55%</td>
</tr>
</tbody>
</table>

* Food retailing sector  ** Using Mexican modern employment share

Table 1: Relative TFP in Modern and Traditional Retail Establishments

underscores the central importance of compositional differences in explaining retail TFP differences. Differences than those based on the census data. I can think of two main reasons. First, my proxy for modern stores using the census is likely to be imperfect, since a number of traditional stores potentially get classified as modern. For example, outdoor markets with more than 20 vendors could conceivably be counted as modern, even though they would be counted as traditional by McKinsey. Similarly, smaller supermarkets might be counted as traditional under the 20 worker cutoff. This would tend to bias the TFP ratio downward. Second, the census employment data is unfortunately just total workers, and not total hours worked, as in the McKinsey data. Since modern stores use part-time workers more intensively, the labor input is likely to be biased upwards for modern stores in the census data, leading to modern TFP that is understated.
2.3 Modern Stores Are Located Mostly in the Largest Markets

I conclude the empirical part of the paper with spatial evidence that market size is an important limiting factor in the limited use of modern retail establishments in developing countries. I show that within developing countries, geographic districts with the highest prevalence of modern stores tend to be the ones with the most income per square mile and highest car ownership rates. I provide details of the calculations in the data appendix.

Figure 3: Modern Store Prevalence and Market Size in Mexico

Figure 3 presents a summary of my county-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, by quartile of the income density distribution, the auto ownership rate and modern store employment share, which I construct as the fraction of food retail employment in supermarkets. Two main findings are suggested by the figure. First, counties with higher income density have substantially higher car ownership rates, suggesting that “larger markets” are characterized by both high income and more cars. This suggests that it is not obvious how to distinguish between the independent influences of income and cars on modern stores prevalence. Second, and most importantly, the prevalence of modern stores is much higher in larger markets. In the largest Mexican markets, many of which are in or around Mexico City.

More precisely, they are municipio-level findings, as a county is called in Mexico.
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 20% or less. Figure

![Figure 4: Modern Store Prevalence and Market Size in the U.S.](image)

shows the same picture for the U.S. It is worth exercising caution when directly comparing the levels for two reasons (not including the different scale on the y-axis). First, the income quartiles on the x-axis are not comparable, as the U.S. has substantially higher income per square mile on average than Mexico. Second, the definitions of modern and traditional stores differ in the two countries due to the differences in data sources used. Nevertheless, the figure serves to highlight two major differences between Mexico and the U.S: the U.S. has high car ownership rates and high modern employment shares in virtually all counties, no matter the income density. One potential interpretation of the graph is that even in sparse areas like Bentonville, Arkansas, widespread car ownership leads to markets sufficiently large enough to support modern retail stores.
3 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.

3.1 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.¹⁶ 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 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 $p_s$.

¹⁶The 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.
3.2 Production Side

3.2.1 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

\[ Y_j = \min[Z_j L, X] \]  \hspace{1cm} (2)

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

\[ mc_j = p_x + \frac{w}{Z_j}. \]  \hspace{1cm} (3)

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.

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

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.\footnote{Except for the zero measure of households who live exactly at the same point as one of the $N$ modern stores.} Before tackling the problem of the modern producer, it is convenient to present and solve the household problem.

\footnotetext[17]{More generally, Vogel (2007) proves that producers choose to locate further away from competitors with lower marginal costs, and closer to higher-cost producers.}
\footnotetext[18]{Except for the zero measure of households who live exactly at the same point as one of the $N$ modern stores.}
3.3 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.](image)

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 $\tau_A$ and $\tau_B$ 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

\[
U = \max\{\log(c_M + c_T) + \log(1 - s_M - s_T) + \alpha A + c_s\} \tag{4}
\]

subject to

\[
p_M c_M + p_T c_T + p_s c_s + p_A A = y \tag{5}
\]

\[
s_M = x \left(A \tau_A + (1 - A) \tau_B\right). \tag{6}
\]

where \(\alpha\) 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.\(^{19}\)

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:

\(^{19}\)The 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, $\alpha$, satisfies

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

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.\footnote{Without the assumption the solution is not quite as clean, although nothing of importance changes.} 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

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

(8)

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

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

(9)

where

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

(10)

Proof See Appendix (B).

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

\[ y > y_s \equiv p_s + p_A \]  \( (11) \)

for households at any distance \( x \), and only households with autos purchase the superior good. \(^{21}\) By the household’s first order conditions, the optimal consumption choices are

\[ c_M = \frac{p_s}{p_M} \]  \( (12) \)

and

\[ c_s = \frac{y - p_A}{p_s} - 1. \]  \( (13) \)

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.

\(^{21}\)I demonstrate this formally in the appendix.
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 then 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.

3.4 Retail Store Profit Maximization Problem

**Single Modern Store**

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:

$$\hat{\Pi} = \max_{p_M} (p_M - mc_M) \hat{Q}(p_M) - wL$$

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

$$\hat{Q}(p_M) = \int_0^{\tilde{x}_B} \int_0^{y_A(x)} \frac{y}{p_M} dG(y) dx + \int_0^{\tilde{x}_A} \left[ \int_{y_A(x)}^{y_s} \frac{y - P_A}{P_M} dG(y) + \int_{y_s}^{\infty} \frac{P_s}{P_M} dG(y) \right] dx.$$  

(15)

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.

**Multiple Modern Stores**

In the case that the profits of a single modern producer, $\Pi$, 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:

$$\Pi(\hat{p}_M) = \max_{p_M} (p_M - mc_M) Q(p_M, \hat{p}_M) - wL$$  \hspace{1cm} (16)

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.

**Proof** See Appendix (B).

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:

$$\tilde{x}_A \equiv \frac{\hat{p}_M / p_M - 1 + \tau_A(1/N)}{\tau_A(1 + \hat{p}_M / p_M)}$$  \hspace{1cm} (17)

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 (16), with $\tilde{x}_A$ defined as in (17).

---

22 Notice that when all stores charge the same price, as will be true in an equilibrium (to be defined below), we have $\tilde{x}_A = 1/(2N)$. This means that each of the $N$ stores service an arc length that extends on both sides a total of $2 \cdot 1/(2N) = 1/N$. 

22
3.5 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 $\tilde{y}_A(x)$, $y_s$, $\tilde{x}_A$, 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 a price $p_M$ from other modern competitors.
3. Modern stores earn zero profits.
4. Given prices, the household decision rules solve the household problem for each possible distance $x$ and income $y$.
5. Markets for the consumption goods $c_M$ and $c_T$ clear.

3.6 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 $\mu$ be the share of employment at modern stores:

$$\mu \equiv \frac{L_M + \bar{L}}{L_T + L_M + \bar{L}}.$$  \hspace{1cm} (18)

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 productivity\(^\text{23}\) to be

$$LP = \frac{Y_M + Y_T}{L_M + \bar{L} + L_T} = \mu LP_M + (1 - \mu)LP_T.$$  \hspace{1cm} (19)

\(^{23}\text{Labor productivity in this model corresponds to TFP. The term "labor productivity" seems more appropriate than "TFP" though since labor is the only factor of production.}\)
Since productivity in the sector as a whole is driven by $\mu$, it is worth characterizing which parameters of the model raise or lower $\mu$.

3.7 Comparative Statics for the Modern Employment Share

In this section I present the main qualitative results of the paper regarding $\mu$, 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.

**Proposition 3** The modern employment share $\mu$ is decreasing in the auto price $p_A$, the fixed cost for modern producers $\bar{L}$, and transport costs $\tau_A$.

The modern share is also increasing in income.

**Proposition 4** Let $\mu_1$ and $\mu_2$ 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 $\mu_2 > \mu_2$.

Each of these effects work through the same channel, which is (in turn) (1) a reduction in modern store profits, (2) a lower equilibrium number of modern stores and (3) a lower modern-employment share $\mu$. For example for the car prices $p_A$, 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 $\mu$.

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 $\mu$.

4 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 sec-
ond, to assess the impacts of policies in the developing that reduce the size of the market for large stores and retail productivity.

4.1 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 allow ten realizations of income, corresponding to the ten deciles of the Mexican household income distribution. Each decile gets weight 0.1 in the distribution. The probability density function of $G(y)$ is given below.

<table>
<thead>
<tr>
<th>INCOME DECILE</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>MEXICO</td>
<td>$839</td>
<td>$2,483</td>
<td>$3,606</td>
<td>$4,807</td>
<td>$6,199</td>
<td>$7,942</td>
<td>$10,210</td>
<td>$13,622</td>
<td>$19,769</td>
<td>$56,837</td>
</tr>
</tbody>
</table>

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 Table 1. 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 $\mu$ 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. The fraction of time spent on the necessity of the richest decile of households is set to 30%, which is broadly consistent with expenditure share data for richer households in Mexico. I set shopping time to be 0.5 hrs per day, which is half of the total reported time spent “shopping for goods and services” in the American Time Use Survey (ATUS). The ATUS data does not distinguish between time spent traveling to stores and time spent inside stores, so I assume 1/2 of the shopping time is travel. In future work I will incorporate more time use data and relative price data from developing countries if possible. The following table summarizes the choice of parameters.

<table>
<thead>
<tr>
<th>CONDITION</th>
<th>PARAMETER</th>
<th>REASON</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>( LP_T = 1 )</td>
<td>Normalization</td>
</tr>
<tr>
<td>2</td>
<td>( LP_M/LP_T = 3.5 )</td>
<td>( Z_M ) Author’s TFP calculations</td>
</tr>
<tr>
<td>3</td>
<td>Car ownership rate = 0.32</td>
<td>( \alpha ) 2000 Census, Brazil &amp; Mexico</td>
</tr>
<tr>
<td>4</td>
<td>( A\text{-HH shopping time} = 0.5 \text{ hrs/day} )</td>
<td>( \tau_A ) American Time Use Survey (ATUS)</td>
</tr>
<tr>
<td>5</td>
<td>( L_M/(L_M + L_T) = 0.19 )</td>
<td>( \tau_B ) Modern employment share in Mexican data</td>
</tr>
<tr>
<td>6</td>
<td>HH with highest ( y ) spends 30% on necessity</td>
<td>( \bar{L} ) Consumer Expenditure Survey</td>
</tr>
<tr>
<td>7</td>
<td>Relative Prices ( p_M/p_T = 0.78 )</td>
<td>( p_x ) Basker (2005), other sources</td>
</tr>
<tr>
<td>8</td>
<td>Traditional Margins ( (p_T - p_x)/p_x = 0.55 )</td>
<td>Census of Commerce, Brazil &amp; Mexico</td>
</tr>
</tbody>
</table>

### 4.2 Market Size and Cross-Country Retail Productivity Differences

As a test of the model’s ability to match cross-country productivity differences in retail, I re-solve the model under the U.S. income distribution, keeping all other parameters the same. The goal of the test is to see whether with the U.S.’s high level of income, the model predicts extensive use of the modern store as in the U.S. data. Just as before, I set the domain of \( G(y) \) to correspond to the ten deciles of the income distribution, only now using data from the 2000 U.S. census. I also multiply the wage rate \( w \) by four, which increases both the marginal costs for both stores and the fixed cost of the larger store.

I find that the model predicts a modern share \( \mu = 0.55 \), up from the original value of 0.19. Given that the U.S. modern share is 0.79, the model’s predictions constitute 60% of the format composition differences with the U.S. As argued in Section 2, composition differences account for 80% of retail productivity differences. Thus the model can account for around 50% – 48% to be exact – of productivity differences in retail. This finding suggests that income differences across countries are a major factor in
determining measured 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.

5 Policy Experiments

In this section I use the parameterized model to evaluate the effects of two policy experiments. In each test I consider the effects on the equilibrium modern share of employment and productivity on a change in one particular parameter. The first is a lowering of the marginal cost of traditional producers corresponding to a crack down on tax evasion. The second is a reduction in the price of owning a car corresponding to the removal of distortions in the market for cars. Since the model is stylized, the results should be interpreted as suggestive rather than conclusive.

5.1 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.

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 2. As the price in traditional stores increases, the model predicts a rise in the share of modern employment from 19% up to 28%, leading to TFP gains of between 1.4% and 12.0%. The results suggest that tax evasion is indeed an important factor in explaining retail productivity differences.
Table 2: Experiment 1: Crack down on Tax Evasion

5.2 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, Barry, 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.\(^\text{24}\)

One perhaps lesser-known policy that a large number of developing countries share is restrictions on the imports of used cars.\(^\text{25}\) 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. As 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.

My model provides a reason to believe used-car import bans are important for un-

\(^{24}\)Other studies for different industries have found evidence of substantially elevated domestic prices for goods in protected industries. Luzio 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.

\(^{25}\)Sen (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.
derstanding low TFP in retailing in countries in which the bans are present. By 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 (2003) 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.26 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 serves as a successful test of the

26Clerides and Hadjiyiannis (2006) 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 (2003).)

5.2.1 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 3. 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 42% 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 lead to sizeable increases in retail TFP on the order of 25%.

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 33% 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 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.

### 6 Alternative Hypotheses & Potential Extensions

#### 6.1 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.

<table>
<thead>
<tr>
<th>Auto Price Reduction</th>
<th>Auto Ownership Rate</th>
<th>Modern Employment Share</th>
<th>Productivity Gains</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>0.33</td>
<td>0.19</td>
<td>-</td>
</tr>
<tr>
<td>-10%</td>
<td>0.35</td>
<td>0.23</td>
<td>+4.3%</td>
</tr>
<tr>
<td>-20%</td>
<td>0.39</td>
<td>0.33</td>
<td>+20.8%</td>
</tr>
<tr>
<td>-30%</td>
<td>0.44</td>
<td>0.38</td>
<td>+26.0%</td>
</tr>
<tr>
<td>-40%</td>
<td>0.51</td>
<td>0.42</td>
<td>+31.9%</td>
</tr>
</tbody>
</table>

Table 3: Experiment 2: Removal of Distortions in Car Markets
Automobiles are just one potential household good that might complement modern 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 here, as markets for fridges do not appear to be as distorted as markets for cars.

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 (2006) 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.

6.1.1 Compositional Differences in Other Services

While retail trade is an important sector, an important question is whether composition plays an important role in explaining TFP differences more broadly. In this section I provide some evidence that compositional differences are important in the service industries more broadly. In Table 4 I calculate relative TFP in the service industries for establishments with less than twenty workers and greater than twenty workers (which I call “modern” here for simplicity), as well as the shares of employment in each size category in the U.S. and Mexico. As in retail trade, the U.S. uses larger-scale service establishments much more intensively, with an employment share of 76% compared to Mexico’s 34%. Measured TFP is also higher in the larger-scale establishments, on the order of 50% to 80% higher than in small establishments. The implied TFP increases from switching to the U.S.’s composition are smaller than in retail, but still not insignificant.

<table>
<thead>
<tr>
<th>Country</th>
<th>Year</th>
<th>Relative TFP</th>
<th>Modern Employment Share</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Ratio 1</td>
<td>Ratio 2</td>
</tr>
<tr>
<td>Mexico</td>
<td>2002</td>
<td>1.8</td>
<td>1.5</td>
</tr>
<tr>
<td>U.S.</td>
<td>2002</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 4: Compositional Difference and TFP in the Service Sector

These findings from Mexico suggest that compositional differences could play an important role explaining TFP differences more broadly, although a more in depth study is in order to draw any firm conclusions. I leave this for future research.
7 Conclusion

In this paper I shed new light on TFP differences across countries using detailed dis-aggregated productivity data from the retail sector, which constitutes one-fifth of the private employment. I document that 80% measured retail productivity gaps 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 and drives TFP. 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. The paper suggests that household time and durable goods such as cars are also inputs into production, and thus should be counted as such when measuring TFP. 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 Relative TFP Measurement

A.1.1 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 $\gamma_M$ and $\gamma_T$ in the following way. For $\gamma_M$, 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. This gives $\gamma_M = 0.5$. To compute $\gamma_T$, I make the assumption that both $M$ and $T$ establishments are price takers in factor markets, and face the same wage rate and rental rate. The firms’ first order conditions then imply that:

$$\frac{w}{r} = \frac{\gamma_M K}{1 - \gamma_M L} = \frac{\gamma_T K}{1 - \gamma_T L}$$

for the given wage rate $w$ and rental rate $r$. Then, using the modern labor share of 0.5 and the relative capital-labor ratio, we can pin down the traditional labor share. In particular, letting $R$ be the relative capital-labor ratio, we have $\gamma_T = \frac{R}{1 + R}$ which, for $R = 2.5$, yields $\gamma_T = 0.71$.

A.1.2 Relative TFP Measurement When $\gamma_M \neq \gamma_T$

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. To see this, rearrange (1) to get

$$\frac{A_M}{A_T} = \frac{\mu_M}{\mu_T} \cdot \frac{V_{AM}/L_M}{V_{AT}/L_T} \cdot \left(\frac{K_T/L_T}{K_M/L_M}\right)^{1-\gamma_M} \cdot (K_T/L_T)^{\gamma_M - \gamma_T}$$

(21)
where the term labeled $B$ is a constant. The term multiplying $B$, however, depends entirely on the units in which it is measured. So even if $\gamma_M - \gamma_T$ is arbitrarily small, the TFP ratio is a function of the units in which capital are measured.

As mentioned in the text, I construct two alternative relative TFP measures using two different assumptions about the units. These again are when the modern capital-labor ratio is set to one, and when the traditional capital-labor ratio is set to one. When $K_M/L_M = 1$, one can back out $A_M/A_T$ from (1). Then, setting $K_M/L_M = K_T/L_T = 1$ the ratio of value added per worker in the two technologies equals $A_M/A_T$, which gives the interpretation the relative efficiency assuming both technologies produced at the $K/L$ ratio of the modern producer. An analogous interpretation arises when $K_T/L_T = 1$.

### A.2 McKinsey Productivity Studies

The studies I employ are Brazil (1995), Mexico (2003) and Russia (1996) (for food retailing), India (1997), and especially Poland (1999a), Thailand (1999b), and Turkey (2001) (for overall retailing). The complete set of reports can be found at [www.mckinsey.com/mgi/rp/CSProductivity/](http://www.mckinsey.com/mgi/rp/CSProductivity/).

The main challenge in measuring retail productivity is measuring output. Unlike manufacturing plants, which have a clearly defined physical output, retail establishments provide a service which is not directly measurable. To the extent possible, McKinsey follows the US Bureau of Economic Analysis (BEA) in their methods for measuring retail sector value added. For example, when establishment-level measures of purchased intermediates are not available, McKinsey uses the BEA’s methodology for estimating gross margins at the establishment level. One limitation of the McKinsey measures is that do not subtract other purchased services, such as electricity.

### 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 Geografía 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

\[
\log\left(\frac{y - p_A}{p_M}\right) + \log(1 - \tau_A x) + \alpha = \log\left(\frac{y}{p_M}\right) + \log(1 - \tau_B x),
\]
which gives an income cutoff of

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

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

\[ \log\left( \frac{y - p_A}{p_M} \right) + \log(1 - \tau_A x) + a = \log\left( \frac{y}{p_T} \right), \]

which gives:

\[ y_A(x) = p_A \left[ 1 - \exp(-a)(1 - \tau_A x)^{-1} \left( \frac{p_M}{p_T} \right) \right]^{-1} \]

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

\[ \log\left( \frac{y - p_A}{p_T} \right) + a = \log\left( \frac{y}{p_T} \right), \]

giving an income cutoff of

\[ y_A(x) = \frac{p_A}{1 - \exp(-a)}. \]

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

B.2 Demonstration that only \( A \)-households purchase superior goods

To show that only households with cars purchase superior goods, start from Assumption 1, which implies that

\[ -a \leq -\log \left( \frac{p_s}{p_s - p_A} \right). \]

By exponentiating both sides and rearranging terms one can show that

\[ p_A (1 - \exp(-a))^{-1} \leq p_s. \]

Now note that \( \psi(x) \leq 1 \), and hence by the definition of \( y_A(x) \) it follows that

\[ y_A(x) \leq p_s. \]
Finally, the first-order conditions for luxuries and necessities consumption for a household without a car imply that luxuries are purchased when \( y \geq p_s \). By the previous equation, however, such a household would purchase a car at this income level. So all households purchasing superior goods must own cars. ■

### B.3 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 \( x^* > \bar{x}_A = \frac{1-p_M/p_T}{\tau_A} \) and any household at distance \( \bar{x}_A \) is indifferent between the closest modern store and local traditional store. In this case each modern store has the problem (14) of a single modern store, and hence earns profits \( \Pi(\hat{p}_M) \) equal to \( \bar{\Pi} \). But if \( N > 1 \), it must be the case that \( \bar{\Pi} > 0 \), which contradicts the zero-profit condition. Thus, there is no such \( A \)-household \((x^*, y^*)\) that does not shop at a modern store. ■

### B.4 Proof of Proposition 3

[To be completed]

■

### B.5 Proof of Proposition 4

[To be completed]

■
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