THREE ESSAYS ON LOCAL FOOD, POPULATION AGING AND PENSION REFORM

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ABSTRACT

The first chapter investigate the influence of the "local" attribute on food prices. After "buying organic", "buying local" has become the latest trend in food marketing. However, it remains unclear whether consumers are paying a price premium for "local." This paper aims to start filling the research gap by exploring the local price premium of packaged lettuce products in the Honolulu market. Hedonic approach and scanner data obtained from actual market transactions are used to study consumers' revealed preference. Contrary to the positive willingness to pay for local food widely reported in previous studies, no price premium is found for local lettuce in the Hawaii market.

The second chapter utilizes the 2011 Nielsen scanner data for the Honolulu fresh tomato market to explore the existence of price premium for local food. Hedonic analysis is conducted to delineate the price impact of the local attribute. Contrary to the widely perceived local price premium in the consumer preference literature, mixed results of price premiums and discounts are discovered for local tomato products. Additional investigation suggests that the prices of local tomatoes are likely influenced by seasonal output fluctuation. The limited market distribution capacity facing local producers may have contributed further to the retail discounting.

The third chapter utilizes an overlapping generation model to explore the welfare consequences of cohort heterogeneity in education and its relative importance compared to population growth and pension reform in the context of population aging. I draw evidence from China's experience of the Cultural Revolution and the following economic transition. Two sources of cohort differences are identified: educational attainment due to the disruption

by the Cultural Revolution, and differentials in labor market returns to education during the subsequent economic development. Such educational disparity have likely resulted in pronounced labor income gap across cohorts. I conduct counterfactual experiments to evaluate the separate impacts of the three structural elements. The results indicate that quantitative impact of cohort educational heterogeneity is not significant compared to population growth rate and pension policy.

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Chapter 1. Is There a Price Premium for Local Food? The Case of Fresh Lettuce Market in Hawaii

With

Matthew Loke and PingSun Leung

1.1 Introduction[1]

"Buying local" has become one of the hottest trends in food marketing in the developed world. In 2011, the European parliament adopted a new proposal to establish local food systems and introduced a new European local food logo to promote locally produced food (FPC 2011). According to the United States Department of Agriculture's National Farmers Market Directory, the number of farmers markets has more than quadrupled from 1,755 to 8,144 between 1994 and 2013 (USDA AMS 2013). A recent online survey by the *Wall Street Journal* indicated that 76.7% of its readers expressed strong or significant interest in buying local food regardless of cost or when handy (WSJ 2012). Several reasons may explain the emergence of the "local food" movement. First, consumers are showing increasing concern for the health related properties (such as organic and pesticide-free) of food coming from unknown sources (Darby et al. 2008; Scott-Thomas 2012). Foods produced by local farms have the natural advantage of being fresher and more flavorful, and are considered more trusted dietary sources. Second, globalization has led to severe decline of small scale local farms and increased concentration of agricultural production dominated by large companies (Arita et al. forthcoming). "Buying local" is a significant part of an effort to support regional economies and employment, especially during tough economic times, and to rebalance the power in the food supply system (Halliday 2011).

Despite widespread public attention, the influences of the "local" attribute on market prices of local food is not well understood. In the existing literature, studies investigating the price aspects of local are divided into two broad categories. The first category explores economic interpretation from the market demand's perspective and studies consumers' willingness to pay. Using stated preference approach and hypothetical survey data, researchers found that most consumers were willing to pay a positive premium for local food (Jekanowski et al. 2000; Loureiro and Hine 2001; Brown 2003; Giraud et al. 2005; Thilmany et al. 2008; Carpio and Isengildina-Massa 2009; Ulupono Initiative 2011; Grebitus et al. 2013).

[1] A revised version of this paper is accepted for publication at Agricultural and Resource Economics Review.

The market demand studies shed useful insights on consumers' perception of "local," although their findings cannot readily conclude the existence of a general local premium. One reason is that consumers may have overstated their willingness to pay. For example, Buzby and Skees (1994) found that among individuals who revealed positive willingness to pay toward organic food, only a small fraction actually purchased them on a regular basis. Another reason is that some attitudinal studies may have over-simplified consumers' decision making process (for example, by assuming local and imported products only differ in origin and freshness, and are equivalent otherwise). During actual shopping, consumers may take into account many other local-related product attributes that are not equal. Thus, stated attitudes may not translate into real purchase under many circumstances.

The second group of research compared retail prices of local and imported food and observed varying degrees of price differences (e.g. Bennett et al. 2007; Pirog and McCann 2009). These research, however, failed to collect and control for information on other relevant product features. Because properties such as weight and type can be equally important impact on product prices, it cannot be identified if the observed price variation originates from locality or from other characteristics.

Hand and Martinez (2010) pointed out that "local" may influence product prices in several ways. To many consumers, the primary reasons for buying local food are freshness and taste. On the other hand, consumers may also be motivated by such needs as supporting local farmers, preserving biodiversity, or protecting the environment. Furthermore, supply side conditions are perhaps less discussed but equally important. Factors such as production cost and seasonal output fluctuations could easily affect prices of local products.

This paper proceeds along this conceptual framework of "local." We attempt to measure the extent to which the local attribute influences price through various channels mentioned above. We utilize market transaction data of fresh lettuce products in the Honolulu market. The hedonic modelling approach is applied to measure how locality and other product traits determine market prices. With implicit information on product quality we are able to control for the quality effect and explore alternative market implications of local. We also estimate consumers' (Armington) elasticity of substitution for product origin and quality. The degree

of substitutability between local and imports provides valuable information with respect to potential market response to price and output changes.

The Hawaii agricultural market is similar in nature to many market areas in the United States. Local production accounts for 11.6% of food sources with the remaining 88.4% being imported (Loke and Leung 2013). One special advantage the Hawaii market offers, however, is its distinct geographic and cultural background, which provides a clear definition for the term "local." This contrasts to most places in the continental U.S., where "local[2]" is very difficult to define. In Hawaii "local food" explicitly refers to all food grown in the Hawaiian Islands, which is in contrast to "imported food" sourced from the continental U.S. or elsewhere. In the market place, most retail stores across the islands display signage of "local" products to differentiate them from imported ones. Therefore, by studying the fresh lettuce products in the Hawaii market, we are able to generate a clearer implication for local food and its related market system.

The rest of the paper is organized as follows. Section 2 provides some background information on Hawaii lettuce market. Section 3 presents the methodology and data. Section 4 shows the results of hedonic models through various specifications, as well as results of the Armington elasticity analysis. Section 5 provides further discussions of the results. The last section concludes this paper.

1.2 Hawaii Market for Lettuce

Lettuce is America's second most popular fresh vegetable (USDA 2012). Per capita consumption of lettuce in 2011 is about 26.2 pounds (Cook 2012). As of 2010, the value of lettuce crops accounted for 19% of the total value for all fresh vegetable crops. The mostly commonly consumed lettuce type is head (Iceberg) lettuce. Meanwhile, consumption of other lettuce types such as Romaine and Leaf has been growing rapidly in the past decades, largely due to the increased popularity of packaged salad greens (Boriss et al. 2012).

[2] For example, Hand & Martinez (2010) documents a number of issues that prohibit a generally accepted definition of "local".

The majority of lettuce production in the U.S. is located in California and Arizona, with output in 2012 equaling 98% of the national total (NASS 2013). Like many other states, Hawaii imports most of the fresh lettuce from California and Arizona, while local production merely amounts to10.7% of total market supply. Despite its small proportion, lettuce production has increased sharply by 52% during the five-year period from 2007 to 2011[3]. Several conditions have led to this strong regional growth in Hawaii, including: 1) public concerns over *E. coli O157:H7* tainted lettuce sourced from California; 2) available hydroponic and aquaponic systems to produce high-quality, high-value crops intensively in local greenhouses; and 3) growing local food movement with increasing consumer awareness of locally sourced produce.

While the iceberg lettuce industry in California is highly concentrated with the top four and top eight shippers controlling 60% and 80% of the market share respectively, the situation is less so in Hawaii. According to the 2007 Census of Agriculture, there were 138 lettuce producing farms in Hawaii. There are about a dozen wholesalers and importers operating in the Honolulu supply chain for fresh produce.

Most imported lettuces are likely marketed in retail and wholesale stores. About 20% of local lettuce is categorized as "processed" and utilized mainly as "fresh-cut" in the food service industry. The majority of the remaining is distributed through intermediated channels such as supermarkets and discount stores, compared to a small proportion through direct marketing channels (e.g. farmers market).

1.3 Methodology and Data

1.3.1 Hedonic Price Model

The hedonic price model was first developed by Lancaster (1966) who argued that consumers derived utility directly from the characteristics or quality attributes embedded in a product rather than from the product itself. It has been successfully applied to the study of an increasing number of food products, including apples (Carew et al. 2012), fresh tomatoes

[3] This figure included head, semi-head and romaine lettuces as reported by the USDA-NASS but not leaf lettuce as it is not reported by the same agency.

(Huang and Lin 2007; Keahiolalo 2013), organic products (Lin et al. 2008; Smith et al. 2009), fresh eggs (Karipidis, et al. 2005; Satimanon and Weatherspoon 2010; Kim and Chung 2011), frozen fish (Kristofersson and Rickertsen 2007; Roheim et al. 2011), and wine (Steiner 2004; Schamel 2006).

Most current framework builds on Rosen (1974) who demonstrated that observed price of a product can be considered as the sum of the prices associated with each of its quality attributes. Although these prices are not explicitly expressed by the market, they can be estimated by employing the hedonic price (regression) model. This regression model is capable of estimating the price of a product as a function of its quality characteristics.

In this paper, we adopt the methodological approach developed by Rosen. The hedonic price model is specified as follows:

$$P_{it}(\mathbf{Z}) = P_{it}(z_1, z_2, \ldots, z_j, \ldots, z_n)$$

where P_{it} is the price of product i at time t, and $\mathbf{Z} = z_1, z_2, \ldots, z_j, \ldots, z_n$ is a vector of n objectively measured attributes that determines the price of the product. Each attribute j can be measured on a continuous scale or by a dummy variable depending on its type. This theoretical model assumes that the market is operating under perfect competition and general economic equilibrium. Therefore, prices are revealed in the market through the usual mechanisms of consumers maximizing utility by selecting available products subject to budget constraints, producers maximizing profits given available technology and factor prices, and market being cleared.

The partial derivative of the hedonic price function with respect to a particular attribute is an implicit or shadow price at equilibrium that reflects both, the maximum price consumers are willing to pay for an additional unit of that attribute, and the minimum price for which suppliers are willing to sell according to their costs. Furthermore, consumers make a decision to purchase the product or otherwise based on the retailers' offered price. Hence, the price collected from retailers is valid in determining the value of attributes by using hedonic analysis without ignoring the consumer side.

In many of the hedonic price studies on food reviewed, linear and log-linear specifications were most commonly used. The interpretation of the log-linear form is straight

forward and represents the percentage change of the dependent variable for additional units of independent variables specified. In this study, we adopt the log-linear specification as used in Roheim, et al. (2011).

1.3.2 Elasticity of Substitution Model

In Armington's (1969) model, it assumes that products are differentiated simply by their production origin. Hence, a consumer treats local and imported goods (lettuces) as substitutes in consumption. And by assuming this consumer has a well-behaved utility function, the consumption decision is consistent with neoclassical theory of utility maximization or expenditure minimization.

The same consumer derives utility from a composite (Q) of imported (M) and locally produced (L) lettuces. Assuming substitution possibilities between M and L, the decision problem is to combine the minimization of expenditures given the relative price and the desired level of Q. Accordingly, Armington's constant elasticity of substitution (CES) utility for Q can be expressed as follows:

$$Q = [\beta M^{(\sigma-1)/\sigma} + (1-\beta)L^{(\sigma-1)/\sigma}]^{\sigma/(\sigma-1)}$$

where M is the quantity of imported good; L is the quantity of local good; σ is the elasticity of substitution coefficient between the local and imported good; β is distribution parameter, calibrated in the demand function.

The first-order conditions of this utility maximization problem imply that the local to import ratio must be a function of the price ratio to satisfy the following:

$$M / L = [(\beta / (1-\beta))(P_L / P_M)]^{\sigma}$$

Taking natural logarithm of this equation, we obtain an estimation equation as follows:

$$\ln (M / L) = \alpha + \sigma \ln [P_L / P_M] + \mu$$

where α and σ are the coefficients to be estimated, with σ being the Armington elasticity of substitution between local and imported lettuce. μ is the random error.

1.3.3 Dataset

The data used to estimate the hedonic and Armington elasticity models are sourced from the *Nielsen* retail scanner dataset©. Scanner data has been utilized effectively to evaluate the demand for eco-labeling in frozen pollock (Roheim et al. 2011), carbonated soft drinks

(Martinez-Garmendia 2010) and fresh eggs (Kim and Chung 2011), and is suitable for studying consumers' revealed preference based on observations of actual purchases.

The dataset is obtained from Hawaii's three leading grocery chains (Foodland, Safeway and Times Supermarket) in the Honolulu metropolitan area (with a total of over 20 stores). It consists of fresh lettuce products with unique universal product codes (UPC) sold over a 52-week period in 2011. Loose weight items were excluded from the dataset, as their product codes are not available consistently across different stores[4]. Other relevant data on lettuce in Hawaii are compiled from the NASS.

The scanner dataset includes 373 fresh lettuce products. Some 42 products recorded sales for at least one week in 2011, among which 23 have complete information for analysis. Selected product attributes include brand, producer, color, type, weight, package option, weekly sales revenue, weekly sales units, and organic origin[5]. All observations can be categorized into four lettuce types (Iceberg, Romaine, *Manoa* and Leaf) in three forms of packaging (wrap, bag and molded tray), totaling of 656 data points[6]. They include 53 observations for Iceberg lettuce, 229 for Romaine lettuce, 147 for *Manoa* lettuce and 136 for Leaf lettuce. No locally produced Iceberg and Romaine lettuces were found. Among the remaining dataset, 104 observations of *Manoa* lettuce and 51 observations of Leaf lettuce are from local farms.

In the market place, local lettuce can be easily recognized by descriptors such as "Produce of Hawaii" and "Island Fresh" on product packaging. In addition, all three chain stores actively promote their local products via in-store shelf displays and weekly newspaper advertisements. Prominent in-store signs are complemented by highly visible shelf tags (e.g.

[4] Whether and how including loose weight products would affect this paper's result cannot be fully determined without a comprehensive comparison of both types of products. From a general point of view, it is unclear what percentages of fresh lettuce is marketed in each form, though both are likely to constitute significant proportions. For the grocery stores under investigation, more than half of fresh lettuce may be sold in loose weight. On the other hand, some distributors such as wholesale stores may exclusively sell products in UPC packages. Compared to loose weight commodities, UPC items usually have better packaging and are more consistent in overall quality.

[5] Information on product weight was obtained from in-store visits and direct contacts with the retailers.

[6] Organic products are excluded due to insufficient observations for meaningful analysis.

"Hawaii Grown," "Local," and "Locally Grown") to capture the attention of store customers seeking to purchase local produce.

Table 1 reports the mean and standard deviation of the lettuce prices. Average prices of *Manoa* and Leaf lettuces are considerably higher than those of Romaine and Iceberg. Likewise, a clear price premium can be observed for local *Manoa* and Leaf lettuces. One limitation of the dataset is that while package options for imported products range from basic wrapping to better forms of protective covering (such as bags and molded trays), local lettuces are packaged exclusively in molded trays. This may have contributed to the pronounced price differences between local and imported products. On the other hand, one should bear in mind that the summary statistics averages out price impacts of a number of product characteristics, and thus it cannot be determined whether the observed price variation is sourced from product origin or other properties. To provide a complete measurement of the marginal effects of all attributes, a hedonic regression model is next specified.

Table 1. Descriptive Statistics of Lettuce Dataset

	Average Price per Pound ($)	Standard Deviation
Iceberg	1.75	(0.37)
local	NA	NA
import	1.75	(0.37)
Romaine	3.42	(2.35)
local	NA	NA
import	3.42	(2.35)
Manoa	9.33	(3.28)
local	11.31	(1.32)
import	4.55	(0.35)
Leaf	8.29	(4.42)
local	11.96	(0.86)
import	6.09	(4.24)

Table 2. Description of Variables in Hedonic Price Model for All Lettuce

Variable	Description	Mean (S.D.)
Dependent Variable		
*Lnprice**	Log of weekly average price per pound	1.52
		(0.74)
Product Origin		
Local+	=1 if produced in Hawaii, =0 if imported	0.27
	=0 if imported from contiguous U.S.	(0.45)
Type		
Manoa+	=1 if product is Manoa/Butterhead, =0 if otherwise	0.26
	=0 if otherwisea	(0.44)
Leaf+	=1 if product is Leaf lettuce, =0 if otherwise	0.24
		(0.43)
Romaine+	=1 if product is Romaine lettuce, =0 if otherwise	0.41
		(0.49)
Iceberg+	=1 if product is Iceberg lettuce, =0 if otherwise	0.09
		(0.29)
Packaging		
Tray+	=1 if product package is molded-tray, =0 if otherwise	0.35
		(0.48)
Bag+	=1 if product package is bag, =0 if otherwise	0.30
		(0.46)
Wrap+	=1 if product package is wrap, =0 if otherwise	0.35
		(0.48)
Color		
Green+	=1 if product is green, =0 if red	0.76
		(0.43)
Weight		
*Lnweight**	Log of product weight measured in pound	-0.28
		(0.53)

Note: *continuous variable; + dummy variable

[a] For the data on *Manoa* and Leaf lettuce, *Manoa*=0 for Leaf lettuce

[b] Note that all local *manoa* and leaf products are exclusively packaged in trays.

1.3.4 Empirical Model

Using information described in the above sections, we specify the hedonic price equation as follows:

$$lnprice_i = \alpha_i + \beta X_i + \varepsilon_i$$

where X is a vector of independent variables and β is the vector of coefficients to be measured. ε is the error term. Table 2 shows a description of all variables used in the regressions[7]. The dependent variable is logarithm of average price per pound for each product sold in each week. Most independent variables are binary variables for product attributes such as packaging, type and origin. Product weight is transformed into the logarithm form, with its coefficient measuring the percentage change in prices in response to a corresponding change in weight.

1.4 Results

Estimation results are presented in Table 3. Hedonic regressions were initially run with two subsets of the data: first including only *Manoa* and Leaf lettuces, and then adding in Iceberg and Romaine. Both regressions exhibits high levels of R^2 and joint significance. This indicates that the included variables were able to account for most of the price variation in the data[8].

[7] The variable "Green" is dropped from the regressions as its coefficients are insignificant across all specifications.

[8] Possible impacts of potential multicollinearity was considered during analysis. We calculated variance inflation factor (VIF) for all variables and concluded that it did not have a large impact on the main result of this paper.

Table 3. Results of Hedonic Price Models

Lnprice	(1) *Manoa & Leaf*	(2) All
Manoa	-0.06***	0.26***
	(0.02)	(0.04)
Leaf		0.30***
		(0.03)
Romaine		0.06**
		(0.03)
Tray	0.72***	0.82***
	(0.04)	(0.04)
Bag	0.26***	0.54***
	(0.04)	(0.02)
Local	0.02	-0.05
	(0.03)	(0.03)
Lnweight	-0.77***	-0.77***
	(0.05)	(0.04)
Constant	1.04***	0.70***
	(0.02)	(0.02)
Adj. R2	0.9655	0.9524
F-statistic	1577.33	1611.57
# of obs	283	565

Note: ***, ** and * denote significance at 1%, 5% and 10% respectively

Column 1 reports regression results for *Manoa* and Leaf lettuces, with imported Leaf lettuce being the baseline product. The *Manoa* category includes *Manoa* lettuce and Butterhead lettuce[9]. Both belong to the head (semi-head) lettuce type and share similar physical characteristics. Leaf lettuce, in contrast, is a non-head variety with loosely bunched leaves and is the most widely planted. In the United States, per capita consumption of Leaf and *Manoa* lettuces is lower than Iceberg. However, demand has been steadily picking up since the introduction of the fresh-cut salad products in the late 1980s (Boriss et al. 2012). The 6% price difference in the regression shows that *Manoa*/Butterhead and Leaf may be viewed as close substitutes to the traditional Iceberg lettuce.

"Tray" and "Bag" are dummy variables for package options, and the default option is "Wrap." For fresh produce such as lettuce, product packaging may be a crucial price determinant, because it is likely correlated with overall product quality and may serve as its indicator. This is for two reasons. First, as better packaging is more costly, it makes practical, economic sense to pack higher value, quality products. Different packaging may thus indicate different levels of grading for product quality, while grading has been used as a proxy for quality in the hedonic literature before. For example, McConnell and Strand (2000) found that grading alone explained considerable part of observed variation in tuna prices. Adding other quality characteristics did not substantially improve their regressions' fit.

Second, better packaging may imply more product processing, and postharvest processing is important for freshly harvested produce to meet proper product specifications and food safety requirement. The processing procedures may include cleaning/prewashing, cutting and packing, so that products are more ready-to-serve, achieve longer shelf life and better quality consistency. These features contribute to overall quality and value of the final product, both of which may significantly influence consumers' purchasing decisions.

The regression result seems consistent with the above notion that quality is correlated with packaging. "Tray" and "Bag" have the highest coefficient values and are both significant at the 1% level. The order of the coefficients are sorted out in a logical way: better packaged

[9] Manoa lettuce is mainly cultivated in Hawaii. It is a very popular choice for salad and can be used in place of any other types of lettuce.

"Tray" and "Bag" products exhibit substantial price premiums against baseline "Wrap" products (72% and 26% respectively), and the higher prices are likely due to better overall quality.

The next variable to be examined is "local". Many consumers buy local food primarily because they are considered fresher and more flavorful, as the farm to market distance is shorter and fruits/vegetables are harvested closer to ripening. In addition to the quality aspect, people may also be willing to purchase local food, simply to support local farmers or for other reasons (see e.g. Hand and Martinez, 2010). If the local attribute could influence prices in more than one way, it would be important to uncover the relative significance of each channel and identify the most essential one.

With product quality being proxied by the packaging variables in the current specification, quality effects would be controlled for, and price impacts of additional local related motivations, if any, would be captured by the coefficient of the "Local" variable. Contrary to expectation, the result reveals that coefficient of "Local" is close to zero and statistically insignificant, reporting no local price effects in ways other than product quality. This result suggests that even though consumers have stated a higher willingness to pay to support local economy, there is no evidence that this is existent in actual transactions. Possible explanations are provided below in the discussion section.

The last variable "Lnweight" measures the influence of product weight. As expected it has a negative sign and shows that a 1% increase in product weight would decrease the price per pound by 0.79%. This is consistent with the practice of weight discounting when purchasing fresh food in single units.

Column 2 reports a parallel hedonic regression applied to the added dataset that includes Iceberg and Romaine. With a more complete product spectrum, the results exhibit larger price variation across different types of lettuces. The more premium types of *Manoa* and Leaf lettuces exhibit 26% and 30% higher prices respectively than the baseline imported iceberg lettuce. Other estimates are quite consistent with the previous specification. Coefficients on product packaging and weight are highly significant, while coefficient of "Local" continually shows no significance.

Given that local may not affect prices through other channels besides product quality, the next question to ask is whether quality is valued differently between local and imports. To answer this one can add interaction terms of "Local" and the packaging variables to the above regressions, and their coefficients would indicate if additional premium is existent for local lettuce. As is noted that all local products are packaged in trays, this specification would not generate meaningful results. One alternative is to compare local and imported products both in trays, so the coefficient of "Local" would capture the quality premium of local lettuce if existent. In this case the regression includes only variables on product type, locality, and weight. The result is reported in Table 4. It is reassuring to find that "Local" is again insignificant. This suggests that quality is valued in the same way by consumers regardless of the product origins.

Table 4. Results of Hedonic Price Models for Manoa/Leaf Lettuce in Trays

Lnprice	Coefficient	Standard Error
Manoa	-0.06***	(0.02)
Local	0.04	(-0.03)
Lnweight	NAa	NA
Adj. R2	0.1041	
F-statistic	11.40	
# of obs	180	

Note: ***, ** and * denote significance at 1%, 5% and 10% respectively

[a]: Coefficient of "Lnweight" is dropped because all imported/local products packaged in trays have same weight.

During the course of analysis, concern about the autocorrelation of weekly sales was brought up. Average retail prices of a good from week to week may not be independent events and any one observation could be correlated with other weekly observations for that UPC. To address this issue, we calculate Durbin-Watson statistic and apply generalized least-squares (GLS) regression to the hedonic models. Estimates from the GLS regressions (Table 5) make moderate changes to the OLS results, indicating that autocorrelation likely exists in the data. However, interpretation of the results is largely consistent with that of the OLS regressions. No significant price impact of the local attribute can be found.

Table 5. Generalized Least-squares (GLS) Results of Hedonic Price Models

Lnprice	(1) *Manoa & Leaf*	(2) All	(3) *Manoa & Leaf (Tray)*
Manoa	-0.07	0.31***	-0.06
	(0.05)	(0.11)	(0.06)
Leaf		0.37***	
		(0.10)	
Romaine		0.29***	
		(0.09)	
Tray	0.72***	0.68***	
	(0.10)	(0.09)	
Bag	0.26***	0.41***	
	(0.06)	(0.06)	
Local	0.04	0.07	-0.01
	(0.07)	(0.09)	(0.07)
Lnweight	-0.72***	-0.83***	NA[a]
	(0.13)	(0.08)	NA
Constant	1.06***	0.61***	2.48***
	(0.06)	(0.08)	(0.06)
Adj. R2	0.9199	0.8226	0.9157
D-W (OLS)	0.30	0.27	0.13
D-W (GLS)	1.92	1.99	1.68
# of obs	283	565	180

Note: ***, ** and * denote significance at 1%, 5% and 10% respectively

[a]: Coefficient of "Lnweight" is dropped because all imported (local) products packaged in trays have same weight.

Finally, we measure the Armington elasticity of substitution between local and imported lettuces utilizing data on *Manoa* and Leaf. The estimated result using GLS regression is reported in Column 1 of Table 6. After correction for autocorrelation, elasticity of substitution is about 2, suggesting a relatively high degree of substitutability between local and imported lettuce when a change in their relative prices occurs. The value itself, however, is lower than what was found previously in the trade literature. Donnelly et al. (2004), for example, report estimates of elasticity that range from 2.2 to 3.9 for fruits, nuts and vegetables using data of three-digit and higher level of aggregation. One explanation is the different nature of the datasets. Our result is calculated with weekly data, which records transactions over a much shorter time period than data collected quarterly or annually. In an extended period of time (longer run), estimated elasticities are often higher due to the effect of trade responses being accounted for or played out (see McDaniel and Balistreri 2002).

Table 6. GLS Estimates of Armington Elasticity of Substitution

Variable	*Manoa & Leaf*	*Manoa & Leaf*		All	
	(1) Local	(2) Tray	(3) Wrap	(4) Tray	(5) Wrap
Elasticity	2.05***	1.59***	1.64***	1.29***	1.74***
	(0.24)	(0.21)	(0.20)	(0.19)	(0.21)
D-W	2.40	1.93	1.95	1.89	2.17
Adj. R2	0.6725	0.5997	0.6368	0.7956	0.6501
# of Obs.	52	52	52	52	52

Note: ***, ** and * denote significance at 1%, 5% and 10% respectively.

For comparison purposes, we also calculate the elasticity of substitution for product packaging using the Armington specification. This is done separately for *Manoa* and Leaf, and for All lettuces. The three package formats are categorized into either tray & nontray, or wrap & nonwrap. Reported results in Column 2-5 of Table 6 show that consumer choices were quite elastic between products in different packaging, though all estimates are lower than the elasticity for product origin. One notable point is that elasticities for tray & nontray are lower than those for wrap & nonwrap. This implies that products in trays are more distinct from those in wraps and bags, as their consumption is less substitutable than divided as wrap & nonwrap categories.

1.5 Discussion

While most consumer demand research found a positive price premium for local food, using hedonic price models with actual transaction data, we could not identify a significant local premium. In addition to the explanations provided in the introduction section of this paper, two other possibilities may help to explain this inconsistent result.

Many studies report that consumers are motivated to purchase local products by their needs of supporting local farmers, or making sure that food production meets certain environment standards, etc. (see Martinez et al. 2010). According to Hand and Martinez (2010), some form of interactions between consumers and producers will be necessary for these specific demands to be met. Since the Nielsen scanner data utilized in this study was obtained from conventional grocery stores, the faceless and impersonal way that local products were marketed may have lowered their prices because it failed to deliver the desired performance outcomes for specific consumer needs.

Another possible explanation is the effects of product branding. While local lettuce production in Hawaii is distributed among a number of small and medium sized farms, several imported products in the data were found to be nationally recognized brands. Martinez et al. (2010) reported that it is often difficult for local farms of smaller scales to supply products with consistent quality and year-round availability. In contrast, large suppliers are more able to meet quality expectation and other product specification (such as volume, transportation, etc.). The credibility and customer loyalty secured by better brand images thus might have further reduced the price gap between local and imported products.

One useful implication from the hedonic analysis is that quality is still the most essential product characteristic that matters to consumers. In addition to quality of fresh harvests, perhaps less noticed but equally important is postharvest processing, which may improve overall quality, value and food safety of the final product. Hence, besides delivering fresh and flavorful local produce, local producers could deliver more value-added features through increased product processing to best capitalize on the superior quality of their products.

The Armington elasticity estimates suggest that consumers' purchases are quite responsive to price changes when faced with products of various origins or packaging[10]. The result that all elasticity estimates for packaging are lower than for locality is consistent with the hedonic models, in the sense that consumption pattern with respect to packaging is less affected by prices, compared to consumption with respect to locality. Since packaging serves as an indicator for overall product quality, this reinforces our findings that quality is still the chief concern for consumers.

The result also generates potentially important implication for local producers and policymakers. Pirog and McCann (2009) found that prices of local products are negatively influenced by output during peak production season. Given consumers' elastic responsiveness to price changes, surplus in local output that may lower the price level would in turn prompt consumers to buy more local goods. According to the elasticity estimate, a one percent decrease in relative prices of local lettuce will result in about two percent increase of its consumption relative to the imports. Hence, as local lettuce currently occupies 10.7% of market share, one possible consequence of expansion in local production may be the increased market share for local products.

1.6 Conclusions

In this paper we explored the local premium in various dimensions for fresh lettuce in Honolulu. Utilizing the Nielsen scanner data© and hedonic modeling approach, consumers' revealed preference was investigated, and the price impact of the local attribute was considered under the market equilibrium of both supply and demand. We measured the separate marginal effects of quality and other channels through which the local attribute could influence product prices. We also estimated the Armington elasticity of substitution to investigate consumers' price responsiveness with respect to product origin and quality.

No local premium was found for the channels being investigated. In contrast to the popular belief that consumers may be motivated by other reasons to buy local, our hedonic

[10] The influence of prices on consumer decision has also been documented by Govindasamy et al. (1998), which found that lower prices is one of the primary reasons for shopping at farmers market.

models showed that price variation was mainly attributed to differences in overall product quality, while quality is valued in the same way regardless of product origin. The Armington analysis provides a similar and consistent result, indicating that consumers' purchase pattern is more stable with respect to quality than locality when faced with price changes.

These findings provide useful implications for producers, retailers and policymakers. On the one hand, the hedonic models indicate that quality is still the most essential price determinant. Hence, producers should focus on delivering high quality products with perceived added value to the discerning market consumers. On the other hand, as consumers appear price-sensitive when choosing products of different sources, policy initiatives to promote local production may lead to a larger market share for local products.

One shortfall of this paper is data availability. The sample did not include local lettuce for every product type and quality level to facilitate a complete comparison. However, limited supply of local products in intermediated distributional channels such as grocery stores may be expected on many occasions. Johnson et al. (2013) pointed out that local producers are often challenged by deficiencies in distribution systems and limited access to the mainstream markets. Therefore, it would be important to investigate the supply chain characteristics of the local food producers for possible appraisal of their potential influence on market prices.

A second development is to look at local price premium of other types of products. Prices could be determined by product attributes in many different ways. For example, freshness may be valued more for some food than for others. It is thus interesting to explore these different relationships and to see whether the findings in lettuce can be extended to other commodities. Furthermore, the meaning of "local" may be subject to change across different locational and market settings. Identifying a regional pattern and its connection with economic and social background could open up another avenue for future research.

Chapter 2. Local Premium or Local Discount: The Case of Packaged Fresh Tomatoes in Hawaii

With

Kristopher Keahiolalo, Matthew Loke and PingSun Leung

2.1 Introduction[1]

After "buying organic", "buying local" seems to be the next big thing in food marketing. Across North America, cultural trends such as the "locavore" and "farm-to-table" movements enjoy growing popularity. Likewise, the number and popularity of farmers markets have skyrocketed in recent years, becoming not only a regular weekly shopping stop for residents but also a great tourist destination for visitors. These examples demonstrate the high demand for local products, reflecting consumers' increasing concern for food safety and environment impact of food supply system (Thilmany et al., 2008). What further promotes the growing demand is the "local" campaign by a number of retailers such as Walmart, Whole Foods and Safeway to increase the availability of local produce.

Despite the growing attention about the "local" movement, there is a surprising lack of evidence demonstrating that consumers are paying more for "local." A number of studies have investigated consumer preference and found positive willingness-to-pay for local products (Loureiro and Hine, 2002; Brown, 2003; Giraud et al., 2005; Darby et al., 2008; Carpio and Olga, 2009; Ulupono Initiative, 2011; Grebitus et al., 2013). While this finding indicates consumers' increasing enthusiasm towards local food, caution must be taken when interpreting the result as these studies are based on hypothetical survey data, in which consumers may have overstated their preference. For example, using Nielsen scanner data, Xu, Loke and Leung (2015) report that no local premium could be found for packaged fresh lettuce in Hawaii. Hence, more empirical research is needed to understand the price characteristics of the local attribute.

This paper attempts to explore the existence of local premium by explicitly analyzing consumers' revealed preference using scanner data sourced from actual market transactions. Market prices are examined for local and imported fresh tomato products in the Honolulu metropolitan market area. As often mentioned in the literature, no consensus has been reached on a clear definition of "local" (see e.g. Martinez et al., 2010). Most markets in the continental United States cannot clearly identify "local food" as the definition they encounter

[1] A revised version of this paper is accepted for publication at Journal of Agriculture and Applied Economics.

is ambiguous and relies on distances or length of time that food travelled between where it is grown and sold. Border cities such as St. Louis, Missouri and East St. Louis, Illinois are particularly confusing. The unique geographic and cultural settings of Hawaii offers an unusual opportunity to study the local attribute, considering that "local food" explicitly refers to all food grown in the Hawaiian Islands, which is in clear contrast to "imported food" sourced from continental United States or elsewhere. A stronger implication for the local food market can therefore be derived from the analysis.

Another interesting aspect of the Hawaii fresh tomato market is that local products account for more than three quarters of the entire market. This is quite unusual considering that local food in general occupies a small market share in the United States (Low and Vogel, 2011). As the market is dominated by local supply, the level of local output becomes a potentially important determinant for market prices. This paper examines the relationship between quantity and price, and explores the potential influence of market supply on local food prices.

Hedonic modelling approach is applied to delineate price impact of the local attribute along with other product attributes. Armington elasticity of substitution is also estimated to measure consumers' willingness to substitute products of different origins. A consistent price discount is identified for local products throughout various regression specifications. Moreover, local price is discovered to be impacted by seasonal fluctuation of local supply. The Armington analysis provides a consistent result that consumer purchase with respect to product origin is found to be quite elastic when faced with relative price changes. It is concluded in the end that a price discount, rather than a premium, is found for local fresh tomatoes in Hawaii.

The rest of the paper is organized as follows. A description of the scanner data used in this study is first provided. Models for hedonic analysis and Armington elasticity are then presented, followed by results and discussions. The last section gives concluding remarks.

2.2 Description of the Data

Scanner data has been successfully applied in hedonic analysis to evaluate the market value for eco-labeling in frozen pollock (Roheim et al., 2011) and various attributes in eggs such as

cage free, organic, fertility, and nutrition enhanced (Lusk, 2010; Kim and Chung, 2011). The Nielsen scanner dataset in this study is sourced from three major grocery chains with a total of 19 stores in the Honolulu metropolitan area. It tracks prices, sales units and select attributes of various products organized by SKUs (Stock Keeping Units) on a weekly basis in 2011.

Information collected in each store is aggregated into 52 observations of average prices and other variables for each product. Random weight (or loose weight) items are not included in the dataset as their SKUs are not consistent across purchases or stores and therefore are not compiled. A total of 1279 fresh tomato products with consistent SKUs is furnished in the original dataset. Products which recorded zero sales during the entire year are removed, leaving 40 SKUs with 1174 observations. These products are classified as *grape* and *cherry* tomato, *regular* tomato, and *other* tomato, which represent 42.41%, 26.21% and 31.38% of total sample weight respectively.

Other available product attributes include producer information, product weight, weekly sales value, weekly sales units, and organic origin. Information on product quality is desired for this analysis but is not available. Organic tomatoes constitute 3.7% of all tomatoes by weight. Information on product origin is not initially included, but is obtained from in-store visits. All local tomatoes are actively marketed by the three grocery chains. In the stores, highly visible shelf tags such as “Hawaii Grown,” “Local,” and “Locally Grown” are displayed to capture the attention of consumers seeking to purchase local food. Among the 40 products with positive sales, 11 are locally sourced, accounting for 57% of the sample by weight. As noted above, local products occupy the majority share of the Hawaii fresh tomato market. Total local production between 2007 and 2011 amount to 77% of the entire market supply. In this regards, the sample is roughly consistent with the aggregate data.

Table 7. Descriptive Statistics of Tomato Dataset

	Avg. Price/lb	Market Share (Weight)	Price Premium
grape & cherry			
all	7.39	100.00%	0.00
local	6.49	29.70%	-0.90
import all	7.60	70.30%	0.21
import nonorganic	6.73	61.58%	-0.66
organic	8.67	8.72%	1.28
regular			
all	3.90	100.00%	0.00
local	3.90	100.00%	0.00
import all	N/A	0.00%	N/A
import nonorganic	N/A	0.00%	N/A
organic	N/A	0.00%	N/A
other			
all	7.25	100.00%	0.00
local	7.04	58.00%	-0.21
import all	7.44	42.00%	0.18
import nonorganic	7.44	42.00%	0.18
organic	N/A	0.00%	N/A
All tomatoes			
all	6.96	100.00%	0.00
local	6.09	57.00%	-0.87
import all	7.54	43.00%	0.58
import nonorganic	7.11	39.30%	0.15
organic	8.67	3.70%	1.71

Note: Price premium is calculated as difference of average prices per pound.

Table 7 provides a detailed description of the data. Most statistics matches intuition. *Regular* tomatoes are on average less expensive than *grape* and *cherry* as well as *other* tomatoes. Local products are present in all three categories. One interesting observation is the consistent price discount in all categories (except *Regular*) for local tomatoes. Although this seems to disagree with the finding of the consumer preference literature, it is quite possible since the summary statistics averages out price impacts of a number of product characteristics. In order to analyze the various sources of price variation and attain a more accurate measure of local's marginal effect, a hedonic price model is next specified.

2.3 Methodology

2.3.1 Hedonic Price Model

One shortfall of the classic microeconomic theory based on consumers maximizing utility and producers maximizing profit is the lack of an effective mechanism for determining the intrinsic value of a product's attributes since these attributes are not traded directly. Under the hedonic hypothesis, individual goods themselves do not provide a consumer utility, but instead are seen as bundles of individually valued attributes, and the value of a good is based upon the utility delivered by these attributes. The hedonic price analysis offers a method to estimate the impact of individual attributes on retail prices. Early adopters such as Becker (1965), Lancaster (1966), and Muth (1966) attribute these values strictly as consumers' value of these attributes. Rosen (1974) extends this into the more widely accepted view that the revealed values are market equilibria representing both consumer preferences and producer costs.

The analytical framework of this paper is based on Rosen's hedonic price theory. Goods in the market are described by n objectively measured characteristics, and therefore can be fully represented by the vector $\boldsymbol{z} = (z_1, \ldots, z_n)$ where z_j describes the j^{th} attribute of the good. It is assumed that there exists a sufficiently large variety, but not necessarily every combination, of potential packages of attributes in the marketplace. Prices for goods are then interpreted as functions of the bundled characteristics, in particular the price p_i of good i is $p_i(z_1, \ldots, z_n)$. Perfect competition is assumed where producers and consumers are price-takers with perfect

information of the market. Therefore prices are revealed in the market through the usual mechanisms of individual consumer utility maximization, producer profit maximization, and market clearing conditions. In this framework, estimated hedonic price effects are neither interpreted as identifying the structure of consumer preferences nor producer technologies but instead are generated through a joint-envelope function of supply and demand.

In recent hedonic literature, linear and log-linear forms are the two most commonly used in hedonic price analysis since they provide a straightforward interpretation of their results. As suggested by Diewert (2003), the log-linear model is selected for estimation. In the log-linear form, results can be interpreted as percentage changes in price. The model takes the following form:

$$\ln(p_i) = a + \sum_j \beta_j * type_{ji} + b * organic_i + c * \ln(pkgsize_i) + d * local_i + e_i.$$

where j indexes the type of tomato (*grape* and *cherry*, *regular*, *other*) and e_i is a random error. The dependent variable is logarithm of price per pound. Independent variables include product type, *organic*, and *local* which are represented as dummy variables. The only continuous independent variable is package size and it is transformed into logarithm form. The inclusion of the constant term allows the coefficients to be interpreted as the percent deviation from the baseline product. For this analysis, imported nonorganic *grape* and *cherry* tomatoes are chosen as the reference product. To factor in seasonal variations and market shocks that may have occurred over 2011, the model is also run with 51 weekly dummy variables. Table 8 provides description of the variables used in the regressions.

Table 8. Description of Variables in Hedonic Regressions

Variable	Description	Mean	SD
ln(pricelb)	Logarithm of average price per pound in dollars	1.88	0.35
pkgsize	Package weight in pounds	0.77	0.17
local	= 1 if product is a local tomato, = 0 otherwise	0.40	
organic	= 1 if product is an organic tomato, = 0 otherwise	0.16	
grape & cherry	= 1 if product is a grape or cherry tomato, = 0 otherwise	0.45	
regular	= 1 if product is a regular tomato, = 0 otherwise	0.11	
other	= 1 if product is another tomato, = 0 otherwise	0.44	

Diewert (2003) points out that weighted models are preferred to un-weighted ones as the results would be more representative of the data and the market. In an un-weighted model a fresh tomato SKU with 100 annual unit sales would have as much influence as one with 10,000 annual unit sales which is not representative. Also, value weighting is preferred to sales unit weighting as sales unit weights will give too little weight to higher valued SKUs and too much weight to cheaper priced SKUs. Therefore, additional specifications are run using weighted least squares (WLS) where weekly observations are weighted by the square root of revenue the SKU generated that week.

As the data contains transaction records over a 52 week period, one concern is that the average retail prices of a good from week to week are not independent events. To get around this issue, weekly observations are combined to pull out the annual average unit price and price per pound for each SKU. Though this leaves only one observation per SKU, or 40 observations, and reduces the degrees of freedom, it is felt that the regression using the annual average prices would result in an estimate which would avoid possible correlation of observed weekly prices.

2.3.2 Armington Elasticity of Substitution

The Armington elasticity of substitution measures consumers' willingness to substitute imported products for local counterparts (and vice versa) when there is a change in their relative prices. Following the Armington (1969) framework, products are differentiated by production origin. Hence, local and imported goods are treated as substitutes in consumption. The consumers' utility function takes the form of constant elasticity of substitution (CES):

$$Q = [\beta M^{(\sigma-1)/\sigma} + (1-\beta)L^{(\sigma-1)/\sigma}]^{\sigma/(\sigma-1)}.$$

where M is the quantity of imported good; L is the quantity of local good; and β is the distribution parameter. σ is the elasticity of substitution coefficient between the local and imported good, which is the primary variable of interest. The consumers' problem is to maximize the composite utility Q given the prices of imported and local goods P_M and P_L. First order condition of this utility maximization problem renders the following equation:

$$M / L = [(\beta / (1-\beta))(P_L / P_M)]^{\sigma}.$$

where import to local ratio can be expressed as a function of their price ratio. Taking logarithm of this equation, one can obtain an estimation equation:

$$Y = \alpha + \sigma X + \varepsilon.$$

where $Y = \ln(M/L)$; $X = \ln(P_L / P_M)$; α and σ are the coefficients to be estimated, with σ being the Armington elasticity of substitution between local and imported lettuce. ε is the usual random error.

2.4 Results

Table 9 reports the results of the model across various specifications. The first two columns provide estimates using ordinary least squares with and without the weekly dummies. Similar to the finding of the summary statistics, the regressions show a 12% price discount for *local* tomatoes over the reference group. Imported *organic* tomatoes display a 16% price premium. Imported *regular* tomatoes are found to be around 13% less expensive than the baseline *grape* and *cherry* tomatoes. As expected, a negative coefficient for *ln(pkgsize)* is found, suggesting that a 1% increase in package size would result in a 0.92% decrease in price per pound. All coefficients are significant at the 1% level. The initial model without weekly variables is able to capture more than half of the price variation in the data. The addition of the weekly dummies makes slight changes to the coefficients, though the adjusted R^2 is improved from 0.5774 to 0.6426 suggesting a better fit.

In the third and fourth specifications, weights are added to represent the value of sales. In particular, each observation is weighted by the square root of the revenue that SKU generated in that particular week. This is the preferred method for hedonic analysis on retail prices as outliers can be included but will not disproportionately influence the results. Compared to the un-weighted models, the price discount for *local* drops slightly. Moderate changes are also observed for the coefficients of product type. Products with larger weight now have less buying discount. There is a clear increase in the price premium of the *organic* products, with its value rising from under 16% to over 19%.

Table 9. Results of Hedonic Regressions with OLS and WLS

ln(pricelb)	OLS	OLS *weekly dummies*	WLS	WLS *weekly dummies*	OLS *Annual*	WLS *Annual*
local	-0.12***	-0.12***	-0.11***	-0.10***	-0.18*	-0.13*
	(0.02)	(0.02)	(0.02)	(0.01)	(0.09)	(0.07)
organic	0.16***	0.16***	0.19***	0.19***	0.17*	0.22**
	(0.02)	(0.02)	(0.03)	(0.02)	(0.09)	(0.10)
regular	-0.14***	-0.13***	-0.08***	-0.08***	0.00	0.00
	(0.03)	(0.03)	(0.03)	(0.03)	(0.15)	(0.12)
other	0.13***	0.14***	0.16***	0.16***	0.15*	0.17**
	(0.02)	(0.02)	(0.02)	(0.01)	(0.08)	(0.06)
ln(pkgsize)	-0.92***	-0.93***	-0.84***	-0.85***	-0.88***	-0.83***
	(0.04)	(0.03)	(0.04)	(0.04)	(0.15)	(0.16)
constant	1.60***	1.56***	1.58***	1.51***	1.56***	1.54***
	(0.02)	(0.05)	(0.02)	(0.05)	(0.07)	(0.07)
Adj. R^2	0.5774	0.6426	0.515	0.6126	0.5896	0.6174
Obs.	1174	1174	1174	1174	40	40

Note: coefficients for weekly dummies are displayed in Table 11.
***, ** and * denote $p < 0.01$, $p < 0.05$ and $p<0.1$ respectively.

In the last two models, weekly observations are combined to create one annual observation per SKU. It is surprising to find that coefficient estimates of most variables are quite similar to the previous models in terms of magnitude. All coefficients on *local* and *organic* are significant, and their estimates are comparable to previous results. Discounts for *local* products are between 13% and 18%. Premiums for *organic* products, on the other hand, range from 17% to 22%. The coefficient of *regular* tomatoes loses significance, while the price premium of *other* tomatoes remains at a similar level. Despite the aggregate nature of the combined data, the model is able to capture a considerable portion of price variation in the data. This serves as a good indication of the robustness of the estimates.

Table 10 reports estimation results of Armington elasticity for the combined dataset. Column 1 presents the ordinary least-squares (OLS) estimate. Durbin-Watson (D-W) statistics is calculated to test for potential autocorrelation problem embedded in the data. As suspected the D-W test rejects the null hypothesis of no autocorrelation at the 1% level.

Table 10. Estimates of Armington Elasticity of Substitution

	OLS	GLS
Elasticity	2.39	1.54
SE	(0.15)	(0.39)
D-W	0.23[a]	2.03
R^2	0.4197	0.6814
Obs.	52	51

[a] indicates failure to reject the null hypothesis of no autocorrelation.

To correct for autocorrelation a generalized least-squares (GLS) model is utilized (Column 2). The final estimate of the composite elasticity is valued at 1.54. While an elasticity between zero and one would imply a complementary relationship, the estimate suggests a fair degree of substitutability between local and imported tomatoes.

2.5 Discussions

The summary statistics and hedonic regressions in the previous sections both identify a price discount for local tomatoes. This result clearly contrasts to the positive price premium reported in previous research. For example, based on consumer survey data, Ulupono Initiative (2011) finds that Hawaii consumers are willing to pay $2.50 per pound more for local tomatoes. The organic premium found here is similar in magnitude to values reported by Huang and Lin (2007) for four regional markets in the United States, which range from 7% to 17%. As local tomatoes comprise the majority of the Hawaii market, prices may be suppressed by surplus in market supply. The scanner data contains only one year observation, which precludes a long term dynamic analysis of output and prices. However, it is possible to examine potential seasonal effects of production fluctuation on market prices.

In a study of local food market in Iowa, Pirog and McCann (2009) finds that during peak season prices of local zucchini and summer squash are becoming more competitive. To view the influence of quantity on prices, Figure 1 shows the monthly output and farmgate prices of fresh tomatoes in Hawaii for 2007. The usual peak season for local tomatoes in Hawaii is from May to September (Hawaii Department of Agriculture). From Figure 1 it is clearly seen that the farmgate price follows an opposite direction as the total production. A simple

regression further identifies an inverse relationship between quantity and price: a 1% increase in total output could reduce the price by 0.59%, with the result being significant at 1% level.

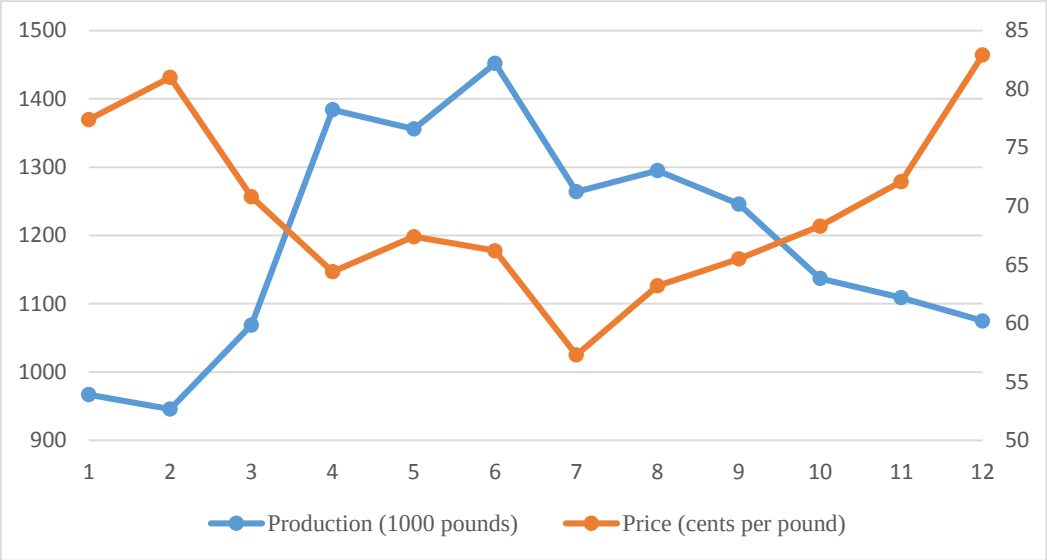

Figure 1. 2007 Hawaii Tomato Production and Farmgate Prices by Month
Source: Statistics of Hawaii Agriculture 2011.
Note: 2007 is the lastest year the data is available.

When the hedonic regressions are run with weekly dummy variables, similar results are revealed. The corresponding time for the local tomato peak season is from week 19 to week 40. Table 11 shows that in both the OLS and WLS specifications, nearly all the variables with negative estimates fall in the range of week 23 to week 41, with about one third of them being statistically significant. In addition, most estimates of the weeks before and after the peak season (week 12-21 and week 42-48 respectively) display positive values with statistical significance, especially for the WLS regression. Since the weekly dummies measure seasonal variations such as supply changes, the time frame of these estimated coefficients, which coincides with the local peak and off-peak season, suggests that the market prices of local tomatoes are likely influenced by output level.

Table 11. Coefficient Estimates of Weekly Dummies in Hedonic Regressions

	OLS	WLS		OLS	WLS
week2	-0.03	-0.02	*week28*	-0.16**	-0.16**
week3	0.06	0.10	*week29*	-0.12*	-0.12*
week4	0.08	0.13*	*week30*	-0.05	-0.03
week5	0.08	0.11	*week31*	0.09	0.15**
week6	0.07	0.09	*week32*	0.06	0.06
week7	0.08	0.07	*week33*	-0.07	-0.03
week8	0.10	0.15**	*week34*	-0.12*	-0.11
week9	0.10	0.15**	*week35*	-0.13*	-0.11
week10	0.00	0.06	*week36*	-0.12*	-0.10
week11	0.09	0.12*	*week37*	-0.14**	-0.14**
week12	0.13*	0.14**	*week38*	0.06	0.13*
week13	0.20***	0.23***	*week39*	-0.03	0.04
week14	0.12*	0.16**	*week40*	-0.03	0.02
week15	0.15**	0.21***	*week41*	-0.09	-0.07
week16	0.12*	0.18***	*week42*	0.11	0.18***
week17	0.16**	0.20***	*week43*	0.09	0.18***
week18	0.15**	0.19***	*week44*	0.09	0.16**
week19	0.14**	0.20***	*week45*	0.10	0.18***
week20	0.13*	0.18***	*week46*	0.11	0.17**
week21	0.09	0.12*	*week47*	0.09	0.15**
week22	0.08	0.09	*week48*	0.09	0.12*
week23	-0.14**	-0.10	*week49*	0.04	0.08
week24	-0.08	-0.05	*week50*	0.08	0.12*
week25	-0.07	-0.03	*week51*	-0.04	0.00
week26	-0.16**	-0.13*	*week52*	-0.14**	-0.13**
week27	-0.10	-0.06			

***, ** and * denote $p < 0.01$, $p < 0.05$ and $p<0.1$ respectively.

Another factor that may have further contributed to the price discounting is the limited market access by local producers in Hawaii. While large national producers with more marketing and logistics competence have access to a larger market, output surpluses can be spread over more market areas with less need for discounting. In comparison, small local farms are often constrained by lack of distribution channels (Martinez et al., 2010). To move inventory, price discounting may be inevitable. In the case of Hawaii, as local tomatoes are exclusively supplied to the local markets, this may result in discounting at the retail level in times of output surplus.

The Armington analysis shows that consumer choices with respect to products of different origins are quite elastic when there is a change in their relative prices. This provides partial evidence suggesting that consumers do not care too much about where their food are grown, which is consistent with the finding of the price discounts for local tomatoes in the hedonic models.

2.6 Conclusion

This paper evaluates the implicit price of the local attribute through the investigation of consumers' revealed preference in the Honolulu fresh tomato market. Hedonic modelling approach and Nielsen scanner data are utilized to delineate the partial effect of "local." Contrary to the widely perceived local premium in numerous consumer preference studies, a consistent price discount for local tomatoes is found through various regression specifications. Additional inspection suggests that the prices are likely influenced by seasonal output fluctuation. As Hawaii fresh tomatoes are exclusively supplied to local market, the limited market outlet may have added to the retail discounting. The high Armington elasticity further suggests that consumers do not care much about product origin.

Moving forward, future research can explore other products and market areas to see if a similar local price discount can be discovered. Moreover, the majority of US farms involved in local food sales are likely relying on direct-to-consumer marketing such as farmers market and community supported agriculture (CSA), etc. (Low and Vogel, 2011). As this paper focuses on the intermediated marketing channel, investigation of consumer demand for local

food in alternative sales networks would be another important step in advancing the understanding of the local food system.

Chapter 3. Population Aging, Cohort Heterogeneity and Pension Reform

3.1 Introduction

China's extraordinary economic development is characterized by several important structural changes. Since the 1970s, the total fertility rate has declined from over five to the current level of below 1.6, largely due to a series of family planning policies. In the meantime, average life expectancy increased from about 64 to 74. As China's economy continues to expand, the country is expected to be soon entering a stage of rapid population aging. The estimated old age dependency ratio, which measures the ratio of population over age 65 versus population between age 15 and 64, will almost triple from 13.1% to 39% between 2015 and 2050 (United Nations, 2013).

The demographic transition, with an expected large elderly population, contributes to the second structural change of the Chinese economy – transformation of the public pension system. Besides the demographic factor, the pension system is being revamped for several other reasons. The original pension system before 1978 covered all formal employment in the state owned enterprises. Since the mid-1990s, however, the government has been actively downsizing the public sector, resulting in the growing imbalance between new contributions and past entitlements. In the meantime, the rapid growth of the non-public sectors called for a more comprehensive pension framework. In light of these changes, a series of reforms have been implemented since 1997 to transform the original Pay-as-you-go pension arrangements into a new nationwide partially funded system.

Population aging and the ensuing pension reform have inspired many interesting investigations of this interactive process in China and elsewhere. Many of these studies have addressed the welfare implications of pension reform across generations. For example, several studies of the U.S. economy have found that welfare impacts of pension reforms often differ between generations (see e.g. Huang et al., 1997; Conesa and Krueger, 1999; De Nardi et al., 1999). One shortfall of the existing literature, however, is that little attention has been paid to heterogeneity among cohorts when evaluating policy changes. For many developing countries or transition economies, such cohort differences may be prevalent and may have long lasting effects. For example, older generations who went through social and political disorder may be negatively affected by these events in health, education and employment

outcomes. Such impacts could eventually translate into lower labor earnings and asset accumulations over life cycle, and render individuals vulnerable to income and expenditure shocks during old ages. In comparison, younger/future generations may not experience similar events such as social and political turmoil. In this situation, neglect of these cohort differences may lead to ill-advised social redistribution policies in the guise of social security and pension reform.

In this paper, I attempt to explore the welfare consequences of cohort heterogeneity in light of the literature gap. In particular, I study the effects of cohort differences in education and labor income as a result of past social and economic events, and compare their relative importance to other elements such as population growth and pension policy[1]. I do so by studying the pension reform in China. The social turmoil of Culture Revolution prior to 1977 and the following rapid economic development provided distinct life experience for many older Chinese cohorts. The Cultural Revolution substantially impacted the schooling performance of many individuals, leading to large differences in educational attainment between older and younger generations. During the subsequent economic development since 1978, such differences has likely turned into a pronounced labor income gap, as labor market returns to education quickly increases while younger cohorts have higher average level of schooling.

I first use the 1990 and 2000 census to gauge the degree of education disparity across various cohorts. Then, I measure the effect of missing education on earnings, by estimating the labor market returns to schooling using the 1995 and 2002 China Household Income Project data. Next, I employ a large scale OLG model and construct counterfactual a labor earnings profile to capture the effect of labor income disparity in a macroeconomic framework. Finally, I use the model and conduct six experiments to evaluate the quantitative significance of population aging, pension reform and cohort differences during China's economic transition.

[1] Cultural Revolution might also have given rise to other potentially important cohort differences in health, employment opportunities, etc. However, accounting for these factors is beyond the scope of this paper.

This paper lies at the intersection of two strands of literature. It contributes to macroeconomic studies of generational equality in the context of social security and pension reform by empirically estimating the impacts of early life events using data from a developing/transition economy. In addition, it adds to the understanding of the long term impact of Cultural Revolution, which has only been explored by a few papers focusing on issues such as education and labor income disruption (see Deng and Treiman 1997, Meng and Gregory 2002, Meng and Gregory 2007, Zhang et al. 2007).

The rest of the paper is organized as follows. Part 2 discusses the educational and labor income disparities resulting from the Cultural Revolution and the increasing return to schooling. Part 3 describes the OLG model, its calibration and the various experiments. Part 4 presents and discussed numerical results. Part 5 concludes the paper.

3.2 The Cultural Revolution, Education and its Impact on Earnings in China

3.2.1 Cultural Revolution and Its Educational Impact

The Great Proletarian Cultural Revolution, an 11-year social-political movement (1966-1976), influenced nearly every aspect of the Chinese society. One of the most disastrous consequences was a complete setback of China's educational system. Starting in 1966, all levels of schools were closed in China's urban regions. Primary and junior high schools were reopened during 1968-1969, although normal curriculum did not resume until the early 1970s. Senior high schools and colleges started recruiting new students in 1972. However, a merit-based college admission system was not implemented until 1977/1978[2].

The Cultural Revolution severely affected formal education of individuals born between 1947 and 1963, a total of 17 birth cohorts (hereafter referred to as the CR cohorts/generations). The disruption takes form in reduced or complete loss of educational opportunity at all levels (ranging from primary school to college), and inferior educational quality because of politically oriented curriculum during the entire period. The disruption

[2] For detailed description of the impact of Cultural Revolution on different levels of schools, see Meng and Gregory (2002).

varied across the CR cohorts as briefly described in Table 12. The most heavily affected among the CR generations were those born from 1947 to 1955, commonly known in China as the "Old Three" and the "New Three" cohorts[3] (hereafter referred to as the Old and New Three, or ONT cohorts), whose education came to a forced stop in 1966 when they were students from fourth grade to senior high school. They were either sent down to the rural regions for political reeducation or assigned factory jobs, until given the chance to compete with fresh high school graduates in 1977 for limited college opportunities. The rest of the CR cohorts suffered less severe loss. They missed part of primary and junior high schools, and were subject to delayed opportunity for college entrance.

Table 12. Educational Disruption for the Cultural Revolution Cohorts

Birth Cohorts	Affected/Missed Education
ONT Cohort	
1947-1955	Primary to senior high school, limited opportunity of college
Rest of CR Cohort	
1956-1957	Primary and junior high school, delayed college
1958-1963	Primary school

Note: ONT refer to the "Old & New Three" cohorts who were born in 1947-1955. The ONT is a sub-group of the CR cohorts.

Table 13 briefly compares the percentage of college graduates for the CR cohorts against previous generations. The values are calculated from the 1982 census, which is the first census carried out after the end of Cultural Revolution[4]. By the time the census was taken, the

[3] The "Old Three" cohorts (born from 1947-1952) commonly refer to those who were in junior/senior high schools at the breakout of the Cultural Revolution. When schools were reopened in 1968, these students were given diplomas, even though they had missed the rest of their junior/senior high school education. After that, they were either sent down to rural regions, or were given jobs in the cities instead of proceeding to higher level of education. The "New Three" cohorts (born from 1953-1955) refer to those who were in 4^{th}-6^{th} grade in primary school in 1966. Unlike the "Old Three" cohorts, they were allowed to continue to junior high schools after receiving their primary school degrees in 1968. However, no formal curriculum was followed. And after graduation, they were not allowed to move onto senior high schools. The majority of them were instead rusticated, just like their predecessors. Hence, both the "Old Three" and the "New Three" cohorts were denied the opportunity of formal education, until they were eventually allowed to participate in the college entrance examination in 1977.

[4] Percentage of senior high school graduates is not reported here, because the difference is not pounced. This is partly due to the fact that even though many members of the CR cohorts (e.g. ONT cohorts) did not finish their senior high school education, they were still granted the diploma.

CR generations were from 19 to 35 years of age (ONT cohorts were 27-35). Although the five-year grouped data can not perfectly distinguish CR and non-CR cohorts, it can still provide some indication of the educational loss born by the former. For example, college graduate ratio of the 30-34 age group, who belongs to the ONT cohorts, is less than half of that for the 40-44 and 45-49 age groups, even though the latter cohort had begun schooling before 1950. The group also has the lowest percentage of college graduates among all CR generations, which suggests that the ONT cohorts were particularly hard hit by the political event.

Table 13. Population with College Degrees in 1982

Age Group	College
20-24	0.90%
25-29	0.81%
30-34	0.79%
35-39	1.42%
40-44	2.19%
45-49	1.62%

Source: Calculated from the 1982 Census of China.
Note: In 1982, ONT cohorts were 27-35, while rest of CR cohorts were 19-26.

A normal tertiary educational system was revitalized in 1978, as indicated by the recommencement of the annual national college entrance examination. After that, many informal schooling opportunities, such as night schools, correspondence schools, etc. quickly sprang up. Members of the CR cohorts actively pursued these informal opportunities to obtain a semi degree for high school or college, as opportunities for official college education were quite limited and competition was fierce[5]. Although this partially offsets the loss of the CR cohorts, there remained a clear gap of educational attainment between the early generations and the younger ones long into the subsequent economic development.

According to Table 14, even in 2000, 22 years after China initiated the economic reform, members of the ONT cohorts still had a much lower proportion of college and senior high

[5] The ONT and other CR cohorts who graduated from high school before 1977 were allowed to participate in the college entrance exam in 1977. However, starting from 1982, the window for the older ONT cohorts was closed, as the maximum age for the exam was restricted to 25.

school degree holders than other CR members and Post-CR cohorts. In addition, the gap broadened particularly for college education from 1990 to 2000.

Table 14. Population with at least some College/Senior High School Education

College	Pre-CR	ONT	Rest of CR	Post-CR
1990	2.57%	1.86%	2.47%	2.92%
2000	3.11%	2.96%	4.55%	5.39%
Senior High School				
1990	6.58%	7.81%	22.63%	13.28%
2000	7.26%	8.82%	21.15%	12.85%

Source: Calculated from the 1990 and 2000 Census of China.

Note: In 1990, ONT cohorts were 35-43, while rest of CR cohorts were 27-34. They were respectively 45-53 and 37-44 in 2000.

3.2.2 Returns to Education

Before China reformed and opened up, it practiced an egalitarian approach for wages under the command economic system. Seniority was more important than productivity or education in determining wage increases (Li, 2003; Zhang et al., 2005). After 1978, China started economic transition with the strategy of incrementally reforming each segment of the economy. Private sector was allowed to grow, while the vast public sector was largely left intact in the beginning. Returns to education initially stayed low, and then quickly increased after 1992 when the government forwarded plans for further reform. Using Mincerian regressions, many researchers find that the return to schooling was below 4% in 1988, but rose to around 10% by the year 2001, a level quite comparable to the 9.9% Asian average (Liu, 1998; Li, 2003; Psacharopoulos and Patrinos, 2004; Fleisher and Wang, 2005; Fleisher et al., 2005; Yang, 2005; Zhang et al. 2005). According to these studies, China's experience is consistent with the trend found in transition economies in Central and Eastern Europe. The increasing returns to education reflects reform of the labor market as well as other segments of the Chinese economy.

As returns to schooling quickly rises, educational attainment becomes more and more important, because higher degrees will lead to increasingly better labor income. To capture the evolving structure of labor earnings in China, I estimate the returns to schooling (and highest degree earned) using the China Household Income Project (CHIP) data in 1995 and

2002. The CHIP data provides representative samples from both urban and rural regions, and I use the urban section of the sample to estimate the returns of schooling on labor income from formal employment, covering full time employed individuals between age 18 and 59[6]. I use a standard Mincer specification for regression:

$$lnwage_i = \alpha_i + \boldsymbol{\beta X}_i + \mu_i$$

Where the dependent variable is the logarithmic value of wage income, and $\boldsymbol{X}$ is a vector of independent variables that may include *years of schooling*, *experience* and its squared term[7], and dummy variables for highest education degree achieved (*college*, *senior high*, *primary* and *below primary* schools). When estimating the returns to highest degree using dummy variables, the baseline group is individuals with junior high school degrees.

Table 15. Returns to Schooling for All Cohorts in 1995 and 2002

	1995	2002	1995	2002
Years of Schooling	0.050***	0.095***		
College			0.351***	0.649***
Senior High			0.156***	0.284***
Primary			-0.139***	-0.203***
Below Primary			-0.189*	-0.491***
Exp	0.046***	0.034***	0.044***	0.029***
Exp^2	-0.001***	0.000***	0.000***	0.000***
Cons.	7.492***	7.517***	7.897***	8.324***
Adj. R^2	0.214	0.211	0.217	0.211
Obs.	10479	9355	10479	9355

Note: Regression is based on data from China Household Income Project (1995 and 2002).

Table 15 displays the returns to schooling for 1995 and 2002. The first two columns use years of schooling as independent variables, while the third and fourth columns regress on a number of school attainment dummies. The results are quite consistent with the existing literature. The return to one additional year of schooling almost doubles from 1995 to 2002. If one accounts for the effects of school degrees, wage differentials across different degrees

[6] The choice of 18 as minimum age is based on both data availability in the household surveys to compute age specific labor earning profiles, and the fact that minimum eligible age for work is 16 in China. On the other hand, mandatory retirement age in China is 60.

[7] Experience is defined as total number of years worked.

become much greater in the seven year period. College degree holds a clear premium of 64.9% against the baseline junior high school, while illiteracy (below primary) is also severely punished.

Table 16. Returns to Schooling for CR and Post-CR cohorts in 1995 and 2002

	1995 CR	1995 Post-CR	2002 CR	2002 Post-CR
College	0.325***	0.441***	0.624***	0.708***
Senior High	0.150***	0.223***	0.261***	0.354***
Primary	-0.138***	-0.269*	-0.213***	-0.280***
Below Primary	-0.227*	0.249	-0.513***	-0.387
Exp	0.037***	0.076***	0.031***	0.056***
Exp^2	0.000**	-0.003***	0.000	-0.001***
Cons.	7.999***	7.745***	8.276***	8.172***
Adj. R^2	0.114	0.118	0.195	0.211
Obs.	6804	2259	5763	3365

Note: Regression is based on data from China Household Income Project (1995 and 2002).

As mentioned above, school curriculum focused heavily on political training before 1978. Also, by comparing Table 13 and 14, one can note that many individuals from the CR cohorts were able to obtain semi diplomas for high school and college through informal schooling. Both irregularities might have affected the quality of education and in turn their labor market return. To examine this possibility, I run separate regressions for CR and Post-CR cohorts[8]. Table 16 reports the results. It shows that although returns to schooling increase for both CR and Post-CR members, the latter earn consistently higher premiums for college and senior high school degrees against the baseline. This confirms the perception that the quality of education under revised curriculum or informal schooling cannot be compared to that of the formal school system, and their diplomas are not considered as equivalent in the labor market. However, another possible reason is that younger generations, who completed schooling and joined labor force at a later stage of the economic reform, were more likely to enter into the non-public sectors that better rewards education. In contrast, most CR members started their career before the early 1980s. In the absence of a mature labor market, they were

[8] However, I do not make further distinction between ONT and the rest CR groups, and assume that they receive similar returns for the level of education they obtained.

assigned jobs in the public sector (e.g. state and collectively owned enterprises), which was not reformed until the late 1990s. The job security and work benefits in the public sector prevented them from rapidly transferring to the fledgling private sector at that time.

3.2.3 Age Labor Earning Profiles and Counterfactuals

Having information on both educational attainment and returns to education, I now start to provide measures for the "missing education" and the unbalanced returns to schooling to account for the educational and labor income disparity between various generations. Counterfactual age earning profiles will then be constructed based on these estimates.

First, I account for the degree of missing education. As shown in Table 14, the ONT cohort was the most affected group due to the forced stop of their high school education and the following massive send-down, as their educational attainment was substantially lower than all later generations. In comparison, the gap between the remaining CR members and post-CR generations was not as evident. This is because the remaining CR members (born 1956-1963) did not endure severe loss of schooling years, though they were still affected by lower education quality. Here, I assume that both the ONT and the remaining CR cohorts received the same "treatment" during Cultural Revolution, and were able to recover their loss to the same extent after 1978. In other words, the average proportion of senior high school and college degree holders among these two groups would be equivalent in both 1990 and 2000[9].

Second, when considering the returns to highest degree earned, I assume that the CR members were able to receive the same labor market return as the post-CR generations. That is, their returns to highest level of schooling should be equal in 1995 and 2002. Separate regressions for the ONT and the remaining CR members indicate that returns to their college degrees are similar but fall behind that of the post-CR groups, while returns to senior high

[9] It would be difficult, however, to argue that all CR cohorts have the same average years of schooling as post-CR members. Hence, this assumption is not made in this paper.

school degrees for the remaining CR members are much lower than the other groups[10]. However, I do not distinguish such differences for the subgroups of the CR cohort.

I construct separate age labor earning profiles for 1995 and 2002 using the CHIP datasets. To do so, annual individual labor earnings from both urban and rural regions are computed for each age group and then weighted by respective age specific labor force participation rates. To build the counterfactual age efficiency profiles, I compensate the CR cohorts with the "missing" education and the differentials in the return to schooling and compute their alternative labor earnings given their "new" educational level and returns to education. The new earnings are then weighted again by labor force participation rate to arrive at an adjusted average labor efficiency profile.

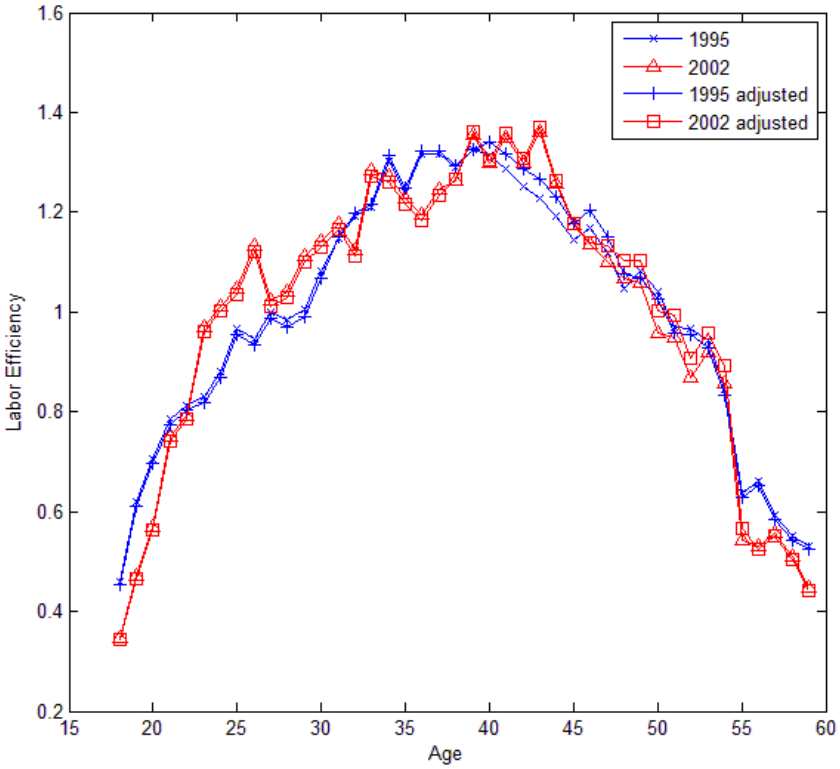

Figure 2. Labor Efficiency Profiles for 1995 and 2002

Figure 2 plots the original and adjusted (counterfactual) labor income profiles for 1995 and 2002. Several points can be noted. First, in 2002 labor earnings of young cohorts under

[10] This likely reflects the deterioration of educational quality for all individuals who took senior high school during the Cultural Revolution.

22 are lower than those in 1995, but rise more quickly and surpass the latter between age 22 and 31. This is because more young people in China are enrolled in schools in 2002, which reduces the labor force participation rate. As a result, average labor earnings for individuals under 22 becomes lower. However, once they finish college and enter the labor market, average labor earnings quickly pick up and overtake the wage level of previous cohorts.

Second, comparing the original and counterfactual profiles, one can note that there is only moderate change in earnings for the CR cohorts. This is likely due to two reasons. On the intensive margin, the economic reform has boosted labor income for both CR and Post-CR cohorts, though the absolute wage differentials at the same educational level are not significantly large, albeit with relative values between 13% (college) and 36% (senior high school). On the extensive margin, while the return to college education seems to rise most, until the education reform in the end of 1990s college entrance in China remains highly selective, and only a very small proportion of its population are college graduates. Hence, even if doubling the proportions of college degrees holders for the CR cohorts, the effect is not quantitatively large, and would be further lessened by labor force participation rates.

3.3 The Overlapping Generation Model

In this section I present the model and its calibration, and then prescribe the various experiments that will be carried out. Following Imrohoroglu et al. (1995), I employ a multiple-period overlapping generation model. Each model period equals one year. Agents in the model are born and start working in period 1, retire at age Jr and live a total of J periods. At the end of each period, there is a positive risk of mortality. The probability that one survives age $j-1$ and moves onto age j is φ_j. The unconditional probability of surviving to age j therefore is given by S_j, where

$$S_j = \prod_{k=1}^{j} \varphi_k.$$

Because of the unexpected death, deceased agents will leave accidental bequests. In this paper I assume that all accidental bequests are discarded by the government instead of being redistributed back to the living agents[11].

The population at steady state grows at the rate of n. The problem of each agent is to maximize the discounted expected lifetime utility

$$E_0 \sum_{j=1}^{J} \beta^{j-1} S_j \frac{c_j^{1-\sigma} - 1}{1-\sigma},$$

where period-wise utility is of the standard CRRA form, β is the discount factor, c_j is consumption at age j and σ is the coefficient of relative risk aversion.

All working agents inelastically supply one unit of labor, and there is no unemployment in this economy. The wage for an age j worker is $w_j^e = w\varepsilon_j$, where ε_j is the standardized productivity of cohort j. Agents receive pension benefits after they retire at age Jr. China' initial pension arrangement takes the simple Pay-as-you-go form, and pension benefit equals a proportion of average lifetime labor earnings, which is depicted in the following equation:

$$b = \theta_{iss} \frac{\sum_{j=1}^{Jr-1} w_j^e}{Jr-1},$$

where θ_{iss} denotes the replacement rate in the initial steady state. This formula indicates that the pension benefit stays the same during the entire retirement periods, and thus is not linked to future wage growth[12]. With these setups, the budget constraint of each agent at age j in this model can be described as:

$$c_j + k_{j+1} = (1+r)k_j + q_j,$$

where k_j is the asset of agent at the beginning of age j, and r is the real return to capital minus depreciation. q_j stands for after tax labor earnings for working agents, where $q_j = (1-\tau)w_j^e$ with τ being the payroll tax rate and w_j^e the efficient wage income for age j

[11] In the initial steady state, total bequests only accounts for only 1.4% of capital, so this assumption should have little impact on the main conclusion.

[12] This feature of the initial pension arrangement will be compared with the pension policy after reform later in this paper.

agents. For retirees, q_j equals pension benefit b_j. In addition, all agents are subject to borrowing constraint, such that $k_j \geq 0, \forall j$, hence agents will not have negative assets.

The technology in the economy is standard Cobb-Douglas production:

$$Y = f(K, L) = K^{1-\alpha}(AL)^{\alpha},$$

where K and L are aggregate levels of capital and labor. α is the share of labor income. A is a labor augmenting technology that grows constantly at g. The depreciation rate is δ.

Government does not have any net worth. Its role in this economy is to collect pension contribution through payroll taxes at rate τ, and discards all accidental bequests at the end of each period. Government budget is balanced in each period.

The time structure of the model is put as follows: at the beginning of each period production takes place first. Capital put aside at the end of last period are used for production and receive corresponding income. In the meantime, working agents supply labor and earn wages, while retirees receive public pension. After that all agents make consumption and saving decisions. At the end of each period some agents of each cohort will die and the assets they leave will be discarded.

At steady states, there is no within cohort heterogeneity: all agents of the same age are identical. For agents of different ages, the heterogeneity arise from two sources: first, the probability they survive to the next age; second, their age specific productivity. As a result, cohorts born in different periods will go through different trajectories of labor earnings, asset accumulation, and therefore have diverse consumption and saving choices during their lifetime.

3.3.1 Steady State Equilibrium

A static equilibrium in this economy is defined as follows:

1. Given market prices $\{w, r\}$, firms solve profit maximization problem, which yields

$$r = (1-\alpha)\frac{Y}{K} - \delta, \; w = \alpha\frac{Y}{L};$$

2. Given prices $\{w, r\}$ and government policy $\{\theta, \tau\}$, household maximizes expected life time utility by solving the following dynamic program

$$V_j(k) = \max_{c,k'}\{U(c) + \beta\varphi_{j+1}V_{j+1}(k')\}, j = 1,2, \dots J$$

where $V_j(k)$ is the maximized value of the objective function of an age j agent with beginning-of-period asset k.

3. Aggregate labor is the summation of labor supply by each working age cohort, weighted by their relative productivity:

$$L = \sum_{j=1}^{Jr-1} \mu_j \varepsilon_j.$$

4. Aggregate capital is the summation of asset holdings by all cohorts:

$$K = \sum_{j=1}^{J} \mu_j k_j.$$

5. Commodity market clears:

$$\sum_j \mu_j \left[c_j + k_{j+1}\right] = f(K, L) + (1 - \delta) \sum_j \mu_j k_j.$$

6. The pension system is self-financing each period:

$$\tau = \frac{\sum_{j=Jr}^{J} \mu_j b_j}{\sum_{j=1}^{Jr-1} \mu_j w \varepsilon_j}.$$

3.3.2 Calibration of the Steady State

I assume that the Chinese economy is at static equilibrium in 1992 and the model is calibrated to this steady state. A total of 68 birth cohorts are considered, which corresponds to age 18-85 in reality. Mandatory retirement age in China is 60, which is age 43 in the model. Most parameters take their long term average values. For example, the share of labor income α is 0.468, which is the average value of 1993-2012, computed directly from available statistical yearbooks. Growth of output per capita g equals 0.037, an average of 1978-1992. There is no estimate of capital readily available for China form official sources, so I follow the approach by Young (2003) and Bai et al. (2006) to construct the capital series from 1978 to 2012. The result is in turn used to compute the average capital output ratio, which is 2.123. The construction also yields a depreciation rate equal to 0.122.

Construction of the age specific labor earning profiles and the counterfactual profiles have been described in the last section. The 1995 labor efficiency profiles are used for the initial steady state (1992), as changes in China's labor market are relatively small in the early

1990s. Pension replacement rate before 1997 is 80%. Mortality data are from average values of 1990-2010 life tables reported by UN (United Nations, 2013) and interpolated using cubic spline to obtain age specific conditional mortality. The growth rate of age one population n is then set to match the UN 1990-2010 average old-age dependency ratio, defined as population of 60-85 divided by population of 18-59. The CRRA coefficient σ is set to be 2, which is commonly used in the literature. Give these values, discount factor β takes the value of 0.986 to match the assigned capital output ratio. Table 17 summaries the calibrated parameters for the initial steady state.

Table 17. Parameters for Initial Steady State

Parameter	Value	Description
J	68	Maximum age
Jr	43	Retirement age
α	0.468	Share of labor income
g	0.037	Growth rate of output per capita
θ_{iss}	0.8	Replacement rate at initial steady state
K/Y	2.123	Capital output ratio
δ	0.122	Depreciation rate
$\{\varepsilon_i\}_{i=1}^{J}$	CHIP 1995	Age efficiency profile
$\{\varphi_i\}_{i=1}^{J}$	UN (2014)	Conditional survival probability
n	0.027	Growth rate of new born
σ	2	CRRA
β	0.986	Discount factor

3.3.3 Transition Paths and Experiments

The initial steady state of the model economy is set to match certain observations of the economy in 1992. Since then, several key aspects of China have undergone critical changes. As a result of population aging, the old-age dependency ratio (defined as 60-85/18-59), which has largely stayed below 20% between 1992 and 2012, is projected to rise to 60% by the year 2049. In the meantime, the original Pay-as-you-go pension framework has been reformed to be a new partially funded system with three components: basic pension, individual accounts and voluntary saving. In addition, as mentioned in the last section, the higher average educational attainment and the rapidly rising returns to schooling have likely resulted in

cohort differences in labor earnings. To evaluate the quantitative impacts of these structural changes, I conduct six experiments and compute the corresponding transition paths of the model.

In the benchmark scenario/experiment, pension policy, age specific labor efficiency profile and growth rate of entry cohorts are set to new formulas/values respectively in period 6, 11 and 20. This is to match changes in pension policy, labor earning profiles and population growth accordingly in year 1997, 2002 and 2011. In particular, n is set to equal to -0.015 so that dynamics of old age dependency ratio will be consistent with projected data. Age specific labor efficiency takes the 2002 profile to reflect corresponding changes. The new pension benefit consists of two parts that will be financed by a payroll tax: a basic pension which amounts to 20% of current average wages in society, and an individual account of 40% of the agents' own wage before retirement. Note that since the basic pension benefit is now targeted to the current wage level, it will be growing at the same rate as wages. In comparison, for both individual account and the initial purely Pay-go pension arrangement, pension benefits stay the same throughout the retirement period. Therefore, the reformed basic pension provides a redistribution function which can reduce potential income gap between retirees and current workers in the context of the rapid income growth. Column 2 of Table 18 lays out the values of the three variables in the benchmark experiment.

Table 18. Values of Population Growth, Pension Policy and Labor Efficiency Profile in Initial Steady State and All Experiments

	initial s.s.	*benchmark*	*population (t = 20)*	*pension (t = 6)*	*efficiency (t = 11)*	*population + efficiency*	*pension + efficiency*
population	**n=**$n = 0.027$	$n = -0.015$	$n = 0$			$n = 0$	
pension	$\theta_{iss} = 0.8$	$\theta_1 = 0.2,$ $\theta_2 = 0.4$		$\theta = 0$			$\theta = 0$
efficiency	CHIP 1995	CHIP 2002			*Counterfactual*	*Counterfactual*	*Counterfactual*

Note: "initial s.s." denote initial steady states respectively. "Population", "pension" and "efficiency" denote respectively scenarios where population growth rate, pension policy and labor efficiency profile in the final steady states are changed alone, while maintaining the values of the remaining two variables as in the "benchmark" scenario.

Next, I change one variable at a time during the transition path, while keeping the other two variables at their benchmark scenario values, to gauge the separate impact of each element. The details are displayed in Column 3-5 of Table 18. For population, I assume the growth rate of entry cohorts n is set to 0 beginning at period 20 for a slowed down aging process. For pension, I assume that public pension program is to be completely removed beginning at period 6. And for labor efficiency profile, I replace original profiles with counterfactual ones for 1992 and 2002 respectively. As noted above, the counterfactual profiles are constructed such that CR cohorts are compensated in both educational attainment and their returns through wages. Hence, the model using the counterfactual profiles essentially eliminates the effects of "missing education" due to Cultural Revolution, and studies individual behaviors in the absence of the historic political movement.

Finally, as a robustness check of the impact of lower labor earnings, I change labor efficiency profiles with one other element (population or pension) at the same time. This is described in the last two columns of Table 18.

3.3.4 Computation of Steady States and Transition Paths

The algorithm to compute the steady states and transition paths can be outlined as follows:

1. Guess (transition series) values of aggregate capital K.

2. Compute (transition series) values of aggregate labor supply L and therefore market prices $\{w, r\}$.

3. Given market prices, solve individual consumption optimization problem at steady state (or along transition) using backward induction and discrete state space approach. Then aggregate the resulting asset holdings for all cohorts and compute new estimates for aggregate capital.

4. If the new estimates of K from step 3 are within reasonable range of the initial guesses, a solution has been found. Otherwise, return to step 1 and update the guesses.

3.4 Numerical Results

In this section, I first briefly discuss the initial and final steady states of the benchmark scenario with some additional experiments. I then move on to make full comparison of the steady states born by all six transition paths. This is followed by detailed examination of main

variables along the transition. In the last part I compare utility gains/loss associated with different policy and structural changes.

3.4.1 Initial and Final Steady States of Benchmark Scenario

I first discuss the initial and final steady states of the benchmark scenario, before comparing it with other experiments under alternative scenarios. Column 1 and 2 of Table 19 summarize the key aggregate variables (prices, capital output ratio and payroll tax rate) in the initial and final steady states of the benchmark transition respectively. As noted above, the benchmark transition process embodies three major structural changes: population growth rate decreasing from 0.027 to -0.015; pension policy reformed from a purely unfunded one (80% replacement) to a mixed arrangements with two government funded components: basic pension (20% replacement) and individual account (40% replacement); and age efficiency profiles changed into a new shape from 1992 to 2002. To evaluate the separate impact of each factor in the steady states, additional experiments are carried out, with results being displayed in Column 3 to 5. The experiment is performed in the way that only one element is changed each time, to see its effect on the final steady state. For example, in Column 3 only population growth rate is set to the value of final steady state, while efficiency profile and pension policy retain their initial steady state values. The same applies to Column 4 and 5.

Table 19. Steady States of Benchmark Scenario

	initial s.s.	*final s.s.*	*pension*	*population*	*efficiency*
r	12.97%	9.99%	13.27%	9.46%	12.21%
w	0.87	1.01	0.86	1.04	0.91
K/Y	2.13	2.40	2.09	2.44	2.20
sstax	4.84%	20.01%	5.82%	17.04%	4.76%

Note: Column 1 and 2 show results of the initial and final steady states for the benchmark scenario. Column 3-5 report key variables when only one parameter is changed each time.

Column 1 and 2 of Table 19 show that because of changes in the three structural forces (population, pension and labor efficiency profile), the benchmark transition to the final steady state will result in a lower interest rate, higher wage and capital-output ratio, as well as a payroll tax rate that grows by more than four times. This is quite consistent with the expectation of an aging society and its need of a much larger pension program, which will be funded by higher payroll taxes.

Column 3-5 decompose the combined effects into influence of each single factor. According to Column 3, although the new pension policy, with its basic part pegged to current wage growth, is supposed to expand the pension expenditure because of the redistributional characteristic, it only has a moderate effect on both prices and the tax rate. Reforming pension policy alone changes the equilibrium payroll tax rate to 5.82%, which is not very different from the initial level of 4.84%.

In comparison, a reduction in population growth rate which leads to a larger share of retirees and a smaller working age population, has two effects. On the one hand, a large share of elderly retirees requires higher payroll tax to fund pension payment, and will put a strain on individual labor income, savings and thus capital accumulation. On the other hand, a smaller working age population means higher capital per worker and capital deepening. The result in Column 4 suggests that capital deepening has the dominant effect, with return to capital reduced to 9.46% in the final steady state. In addition, compared with other two structural changes, i.e. pension and labor efficiency profile, the influence of a slower population growth is still most pronounced. Change in population alone raises capital output ratio to 2.44 and payroll tax rate to 17.04%, which are very close to the final steady state values displayed in Column 2.

Alteration in the labor efficiency profile has the smallest effect on the macroeconomic variables, as shown in Column 5. This is due to two reasons. First, the modified profile mostly reflects adjustment of relative earning ability of different cohorts, yet the magnitude of the adjustment is not very large, as can be seen in Figure 2. Second, the age specific labor efficiencies are multiplied by number of workers to arrive at aggregate labor supply. The calculation using the alternative labor profile, however, only generates a slightly less total labor supply.

3.4.2 Steady States under Alternative Scenarios

Table 20 shows the initial and final steady states in all six transition experiments. Compared to the benchmark final steady state where population growth equals -0.015, setting n equal to 0 instead of -0.015 results in a larger share of working-age population, thereby lowering the level of capital per worker. This raises the interest rate and the capital output ratio, while

lowers the level of wage. The small proportion of retirees also corresponds to a much lower 12.6% payroll tax rate.

In comparison, eliminating the pension program has the largest impact on factor prices and capital intensity in final steady state. Without a pension benefit as insurance for consumption after retirement, individuals have to save more in order to finance their old-age. This leads to an interest rate of 5.29% and wage level of 1.32 (Column 5).

Comparing cases with original and counterfactual labor efficiency profiles, one can note that those with counterfactual profiles have a slightly higher interest rate and lower capital output ratio, though the wage level is almost the same. This is because the counterfactual profiles, with compensation for the CR cohorts, essentially generates a larger aggregate labor supply and hence a lower level of capital per worker.

Figure 3 displays the cross sectional age asset profiles for the steady states. In all experiments, individuals do not start to save until around age 25 (age 8 in the model), because they are subject to the borrowing constraint during early stages of their life. In the final steady states where public pension is reformed to the "three pillared" system (see dashed blue lines and red lines), individuals accumulates fewer assets than in initial steady states due to the higher payroll taxes and better pension benefits that targets the current wage level. However, if pension is completely removed, individuals have to rely on their own savings to provide for old age consumption. This results in the higher level of assets accumulation over the life cycle, and explains why assets peak at the last working age and then quickly decline (see purple lines).

Table 20. Steady States of All Six Experiments

	benchmark	*efficiency*	*benchmark*	*population*	*pension*	*efficiency*	*population + efficiency*	*pension + efficiency*
	initial steady state		*final steady state*					
r	12.97%	13.10%	9.99%	10.48%	5.29%	10.05%	10.59%	5.41%
w	0.87	0.87	1.01	0.98	1.32	1.01	0.98	1.31
K/Y	2.13	2.10	2.40	2.35	3.04	2.39	2.33	3.02
sstax	4.84%	4.85%	20.01%	12.60%	0%	19.87%	12.54%	0%

Note: This table compares the initial and final steady states of all six transition experiments.

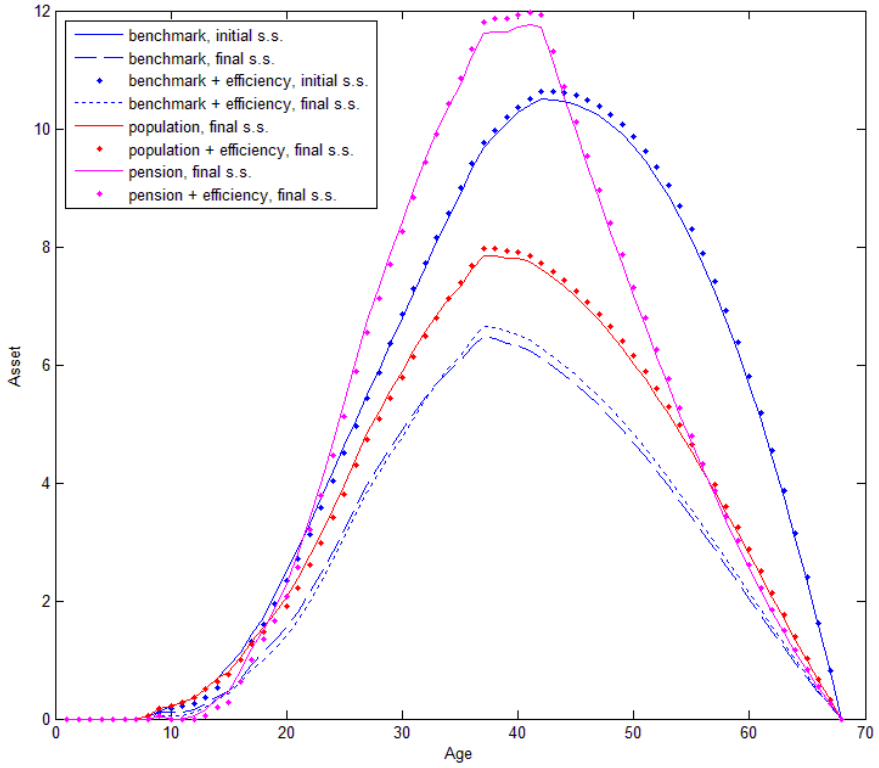

Figure 3. Cross-section Profiles of Asset Holdings

Note: "initial s.s." and "final s.s." denote initial and final steady states respectively.

Figure 4 plots the cross sectional consumption profile. Because the interest rate is the price of inter-temporal consumption, the decline in the returns to capital in the final steady states results in a flatter consumption profile than in the initial steady states. The effect is most pronounced in the experiments where public pension is completely dropped, as consumption quickly declines after it peaks around age 29. However, this does not mean that the level of consumption actually falls, as the graph is cross sectional in nature and does not account for the rapid growth of consumption per capita over time. Comparing the various graphs, it can be noted that the removal of public pension generates considerably higher levels of consumption at a young age than other scenarios. This is attributable to the higher wages and the absence of taxes as a result accordingly.

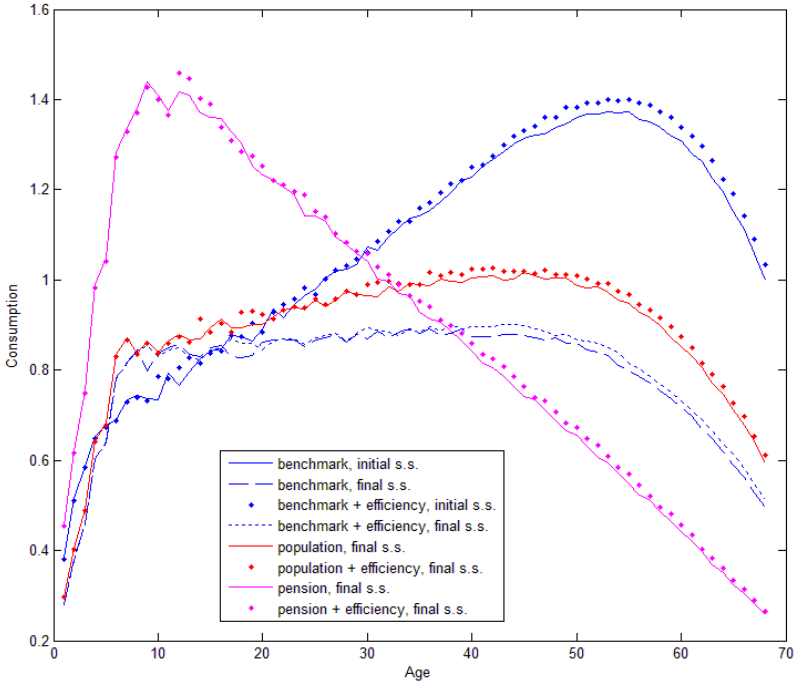

Figure 4. Cross-section Profiles of Consumption

The effects of using alternative labor efficiency profiles are quantitatively small but visible. In both Figure 3 and 4, experiments with counterfactual profiles generate lower assets and consumption for the younger cohorts, compared to higher assets and consumption for older generations. This is mainly because the higher interest rates generated in the counterfactual cases is beneficial for the elderly, who are the main holder of assets, while the lower wages make the life at early stages slightly worse off, because young agents mainly rely on wage income.

3.4.3 Transition Paths

Figure 5 to 9 display the transition paths of the key variables of the economy, such as factor prices, tax rate, per capita levels of capital and consumption. All experiments take about 120 periods to converge. Keep in mind of the structural forces at work behind these experiments: there will be a big reduction in population growth rate; pension benefits will be adjusted (or eliminated); and efficiency profiles are to be adjusted. For all experiments, the gradual decline of the proportion of working age population will slowly increase individual capital level to peak around period 50. After that, the effect of lower interest rate and more generous pension benefits become more pronounced and induce agents to save less. In the benchmark

experiment, capital per capita drops to a level even below that of the initial steady state, likely due to the particularly high payroll tax rate and the smaller share of working age population. In contrast, if population growth is set to be zero, long run capital settles above the initial steady state level.

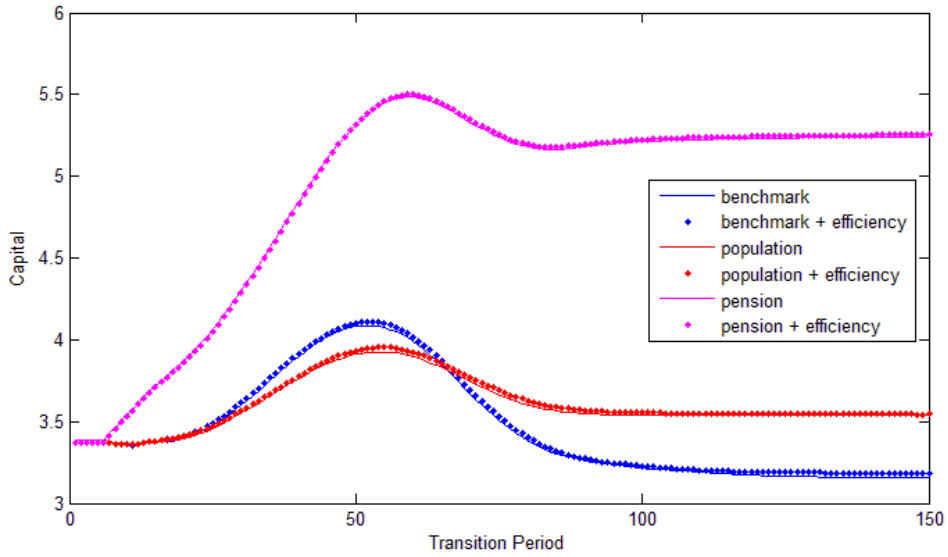

Figure 5. Capital per capita through Transition

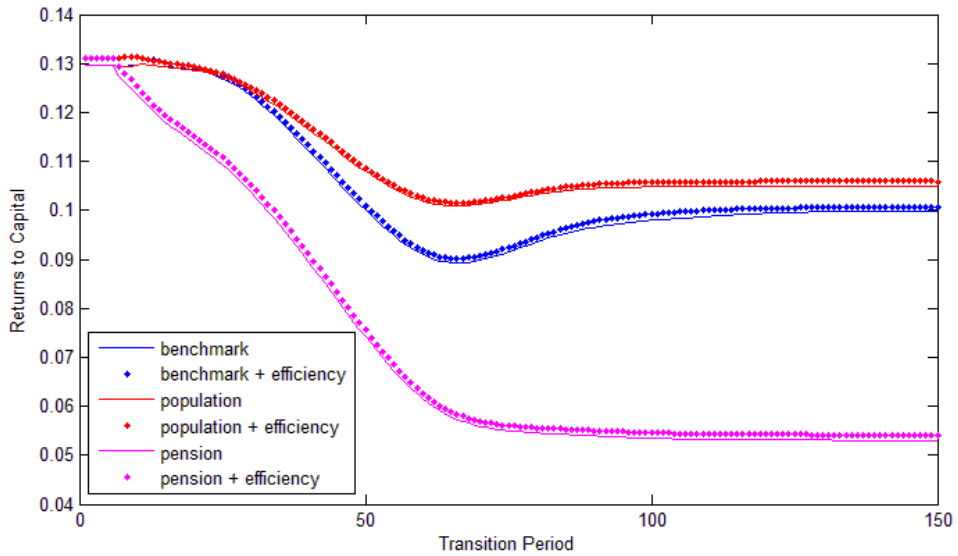

Figure 6. Interest Rate through Transition

The termination of public pension has the largest long term effect on the aggregate variables. Combined with the demographic change, capital in the last two cases (purple lines) rises most rapidly upon the inception of the transition. As retirement accounts for more than a third of total lifetime, individuals need to accumulate a larger amount of assets during their

working years. Therefore, capital per capita reaches a substantially higher level. In the meantime, since the pension reform is non-compensatory in nature, existing retirees and workers who have contributed to the pension program lose their entitlements to the benefits and have to start saving more. Hence, per capita consumption falls to below the initial steady state level after the start of the reform. After that, the rapidly rising wage and per capita capital induced higher consumptions, before being reduced by the rising payroll taxes (Figure 8).

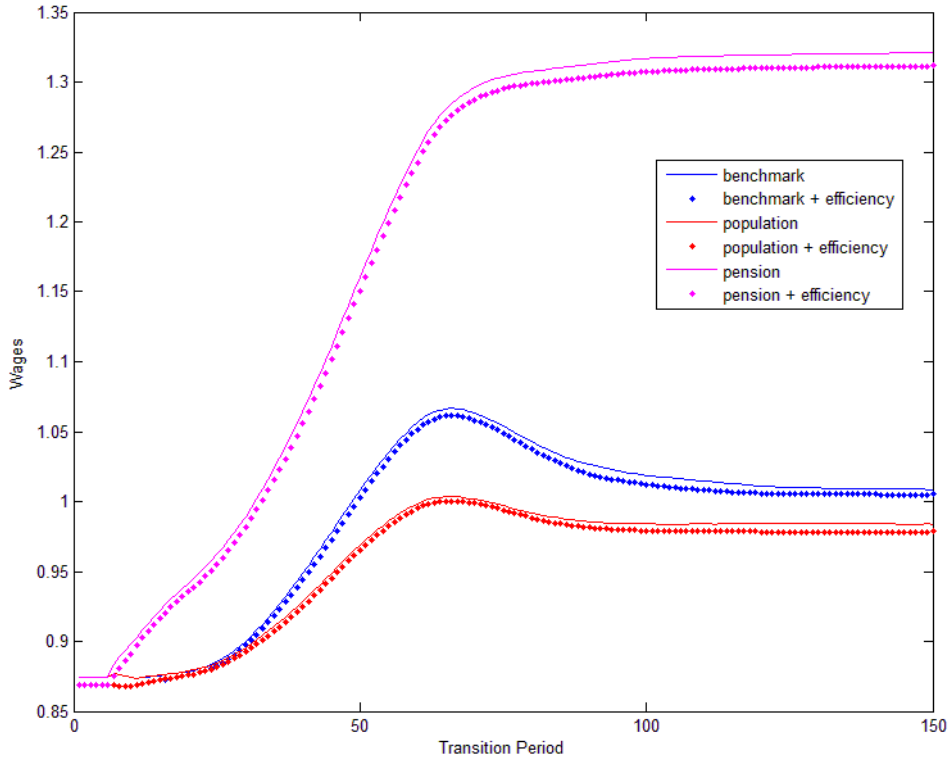

Figure 7. Wage through Transition

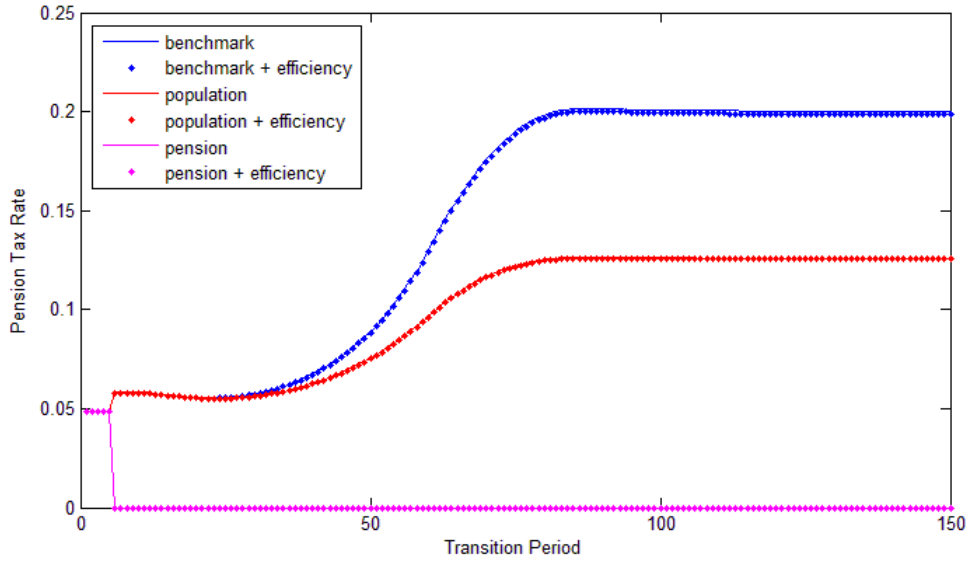

Figure 8. Payroll Tax Rate through Transition

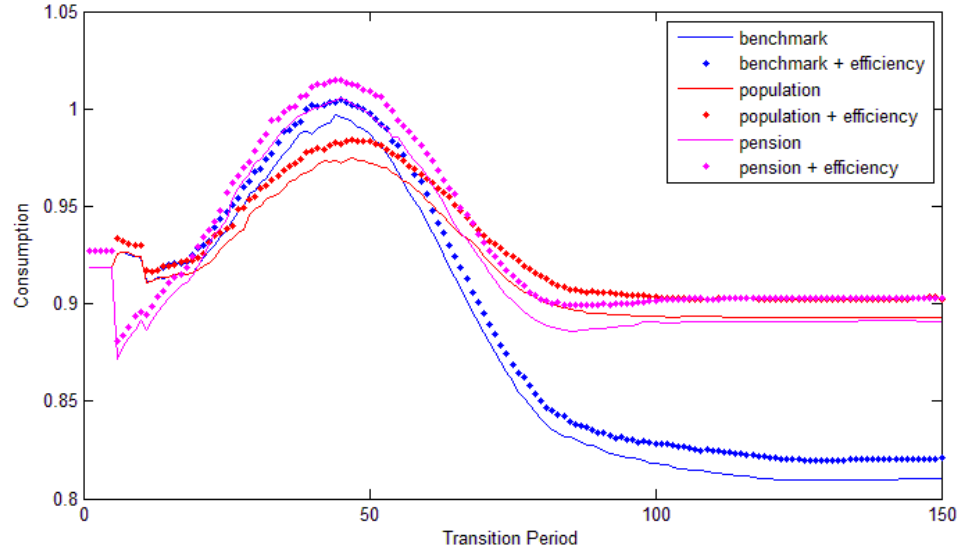

Figure 9. Consumption per capita through Transition

The cost of massive population aging is best revealed in the final section of the consumption paths in Figure 9: a larger share of the nonworking population reduces the economy's average saving, which eventually imposes downward pressure on the average consumption[1]. The effect is especially manifest in the benchmark case (blue lines), where a hefty payroll tax is levied on the young working cohorts. In contrast, having a lowering tax

[1] This is also shown in Figure 10 and 11 using the benchmark experiment as example.

rate through either self-financing (purple lines) or as a result of a smaller retired population (red lines) will raise consumption by a noticeable proportion.

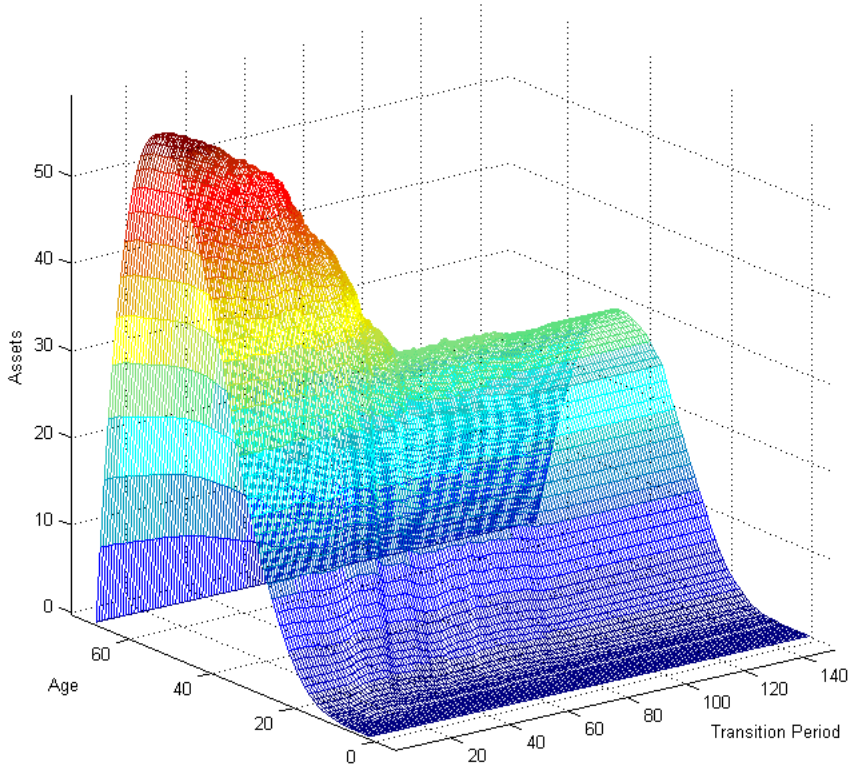

Figure 10. Cross Sectional Asset Profile through Benchmark Transition

The impact of a counterfactual efficiency profile on consumption is not clear at the beginning of the transition, but slowly builds up as it proceeds. In all the scenarios, the counterfactual cases yield higher average consumption, largely due to the greater labor supply. This provides additional evidence that higher population growth (rather than reduction) for China might have positive welfare implications.

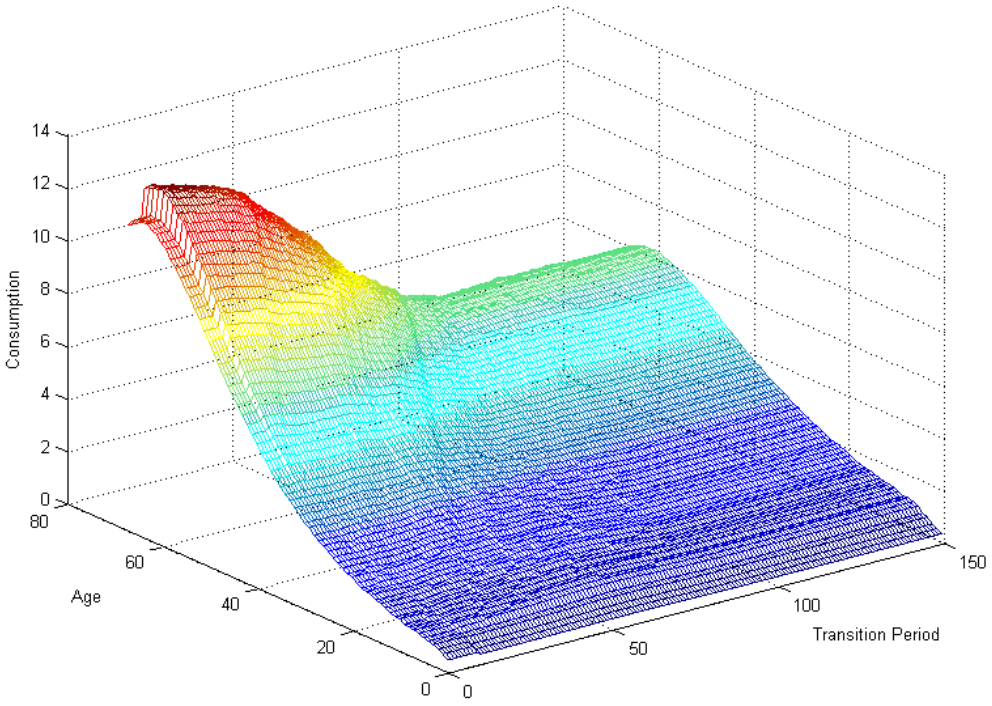

Figure 11. Cross Sectional Consumption Profile through Benchmark Transition

3.4.4 Expected Utility and Consumption Compensation

Finally, expected lifetime utility for all the cohorts that will be affected by the structural changes of the Chinese economy are calculated. Consumption equivalents are evaluated for cohorts under alternative experiments against the benchmark scenario by computing the percentage of consumption individuals in the benchmark case need to be awarded during all periods of their life to make them as well off as in the alternative cases. For example, a supposed result of 5% consumption compensation for cohorts born in 1950 in an alternative experiment means that this cohort needs to be awarded 5% more consumption each period in the benchmark case in order to have the same expected lifetime utility as in the alternative case.

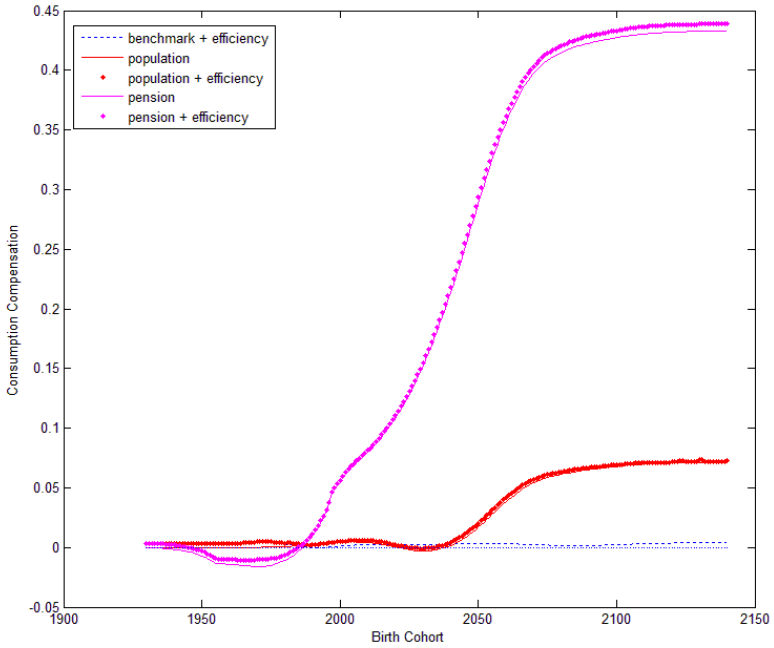

Figure 12. Consumption Compensation of Alternative Experiments against the Benchmark

Figure 12 characterizes the consumption compensation of each experiment for different birth cohorts along the transition. In general, all three structural changes would benefit future generations, while in the case of removing public pension, this benefit is at the cost of existing generations who are born before 1987.

Elimination of the public pension system generates the largest utility gains for future generations but levies a toll on the current ones: an enormous gain of 43.91%, while loss amounting to 1.6%. The loss arises because existing generations lose entitlements in a pension system that they have contributed to for years of their working lives, and have to "restart" saving, while in the meantime interest rate is reduced so that less income can be received from accumulating capital. Future generations, in contrast, receive much higher wages that is free of payroll taxation. However, the loss of current generations is considerably smaller than future gains, likely due to the rapid technology growth and thus growth of per capita output.

The role of a slower population aging process is less pronounced than pension reform: its main impact is on the cohorts born after year 2050, with a utility gain of about 7%. The gain

largely results from a lower payroll tax rate, as a small retired population imposes less fiscal burden on the working cohorts.

In comparison to the demographic and pension factors, the impact of counterfactual efficiency profile is positive on virtually all generations in all scenarios, and is independent from the other two factors. This is because a larger labor supply as a result of the compensated labor productivity contribute to larger output that benefits all cohorts in the economy. In particular, older cohorts born before 1970 benefit more from the reform, who would receive an average of 0.37% more consumption during each period of their lifetime. Meanwhile, the effect on individual's lifetime utility is quantitatively small, though this does not mean that they are insignificant.

Several reasons might have led to this result. First, as discussed in section 2, college graduates, who benefit most from the reform, accounts for a small portion of total population. Second, return to education for senior high school graduates, and its income differentials between CR and Post-CR cohorts, are not much. The compensation of labor efficiency is further averaged out among all members of the same cohort, as no within-cohort heterogeneity is assumed. Consequently, the counterfactual profiles do not diverge substantially from the original profiles. In addition, since the initial steady state of the model is set to be 1992, using the counterfactual labor efficiency profile may not substantially change individual's labor income and wealth, as individuals might already have accumulated a large amount of assets. For example, for the most impacted ONT cohorts who were born in 1947-1955 (age 20-28 by 1992 in the model), Figure 2 shows that they have built up large portion of their life time assets in the initial steady state, therefore limiting the quantitative effect of the compensated labor income.

3.5 Conclusion

For many countries rapid population aging is no longer just "on the horizon," but has already started. Current economic analysis and policy debate are often centered on developed economies, with the typical assumption that all cohorts start equal. Little attention, however, has been paid to developing countries and transition economies, where large cohort differences with important long term impacts might have existed due to political turmoil or

other tumultuous events. In this paper, I investigate this issue by exploring the distinct life experience of many Chinese cohorts who went through both the Cultural Revolution and the subsequent economic takeoff.

Six transition experiments with alternative pension policy, demographic and labor income scenarios are conducted to quantify the relative importance of each structural factor. According to the results, a reform that completely eliminates the public pension system has the largest welfare impact on future and current generations. Future cohorts will benefit substantially from the ensuing rise of capital, while existing workers and retirees will be worse off due to the uncompensatory nature of the reform. However, the future utility gain is much larger than the current loss in magnitude, likely due to the rapid growth of per capita output. Slowdown of population aging will also generate sizeable effect, although mainly for future cohorts who will assume a larger fiscal burden because of a falling share of working age population. This suggests an urgent need for China to adjust its current family planning policy in order to deter the continually falling fertility rate.

Cohort difference in labor efficiency has the smallest quantitative effect, compared to the other two factors. However, this by no means suggest that Cultural Revolution and the absence of a well functioned labor market prior to China's economic reform has no effect on individuals' labor income and thus consumption and saving choices over their life cycle. For individuals who would receive better education and higher labor income in the absence of the Cultural Revolution, the effect of the change on their lives and on the Chinese society would be gigantic, given the sheer size of population affected. One likely reason of the result is the assumed within-cohort homogeneity that averages out the effects of labor efficiency compensation. In this sense, the analysis of this paper largely focuses on implications for cohorts rather than individuals. Future research can further explore this point by introducing intra-cohort heterogeneity into the model to better capture the consequence of missing education on individual well-being.

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