AN EMPIRICAL STUDY OF THE TEA INDUSTRY: INVENTORY MOVEMENTS AND DEMAND

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Introduction

There has been an extensive literature that tried to grasp the role of inventory fluctuations in the business cycle.[1] Many attributed the surge in the GDP of the U.S. in the last quarter of 2009 to the rise of inventory levels in the wholesale and manufacturing sectors to before crisis levels. This paper is aiming at evaluating the relationship between inventory levels and demands for goods (sales) in the tea industry.

The economic importance of tea is not comparable to other commodities such as wheat, coffee or gasoline in terms of consumption in absolute levels; however, it has similar features to those mentioned. It is clearly similar to commodities as it is more or less homogeneous. There is no difference biologically between tealeaves that are plucked, but through value added production they are transformed into a limited number of beverages and products to consumers. The case is the same for coffee or the different types of ores.

Tea furthermore has a health effect that is deeply rooted in the public awareness around the globe. Unlike during the early 20th century, when good quality tea was only a beverage to the higher classes and represented their status within society, nowadays, due to the open media it is widely known that it is beneficial for overcoming a cold, losing weight, cleaning poisonous material out of the blood flow, and helping in staying awake.

Due to multinational companies and their marketing activities, such as Lipton, Twinings, Rauch, Nestle, tea consumption has become fashionable to some respect. It is relatively cheap to acquire and available in nearly all grocery stores across world. As in the case of Hungary it is also included in the measure of the CPI.

[1] Blinder and Eakin (1984), Kahn (1990), Alessandria et al. (2008), Cooper and Haltiwanger (1983).

Tea as a commodity, however, is produced in once-before colonial countries. The list includes India, Sri Lanka, China, Kenya, Thailand, Indonesia, and South Africa. There are only a few countries for, which the description would not fit, which include Japan and Turkey. Despite the fact that in the tea producing countries the population drinks tea regularly, they are mostly lagging behind per capita consumption compared to some European countries. It is not surprising that the per capita consumption of tea is the highest in the United Kingdom with 2.1 kg per person per annum in 2004.[2]

In order to fully grasp the underlying industry one has to be aware of the global structure of it. Figure 1 depicts the setup of the global tea industry. There are three levels: the producers of raw tea; the wholesalers who undertake production activities and create value added; and lastly retailers, who sell directly to consumers. Besides the previously mentioned set up there is a geographic constraint due climate restrictions. Tea can only be grown and harvested in tropical and Mediterranean climates. This explains the restriction in the location of harvesters of raw tea to former colonial countries mostly. Therefore, there is a shipment cost and a lag in acquiring the raw tea. Also, it would make costs of acquisition of raw materials highly volatile due to fuel prices. In reality, however, based on an interview conducted with a member of a large wholesale company based in Hamburg, it can be stated that these costs are limited through contractual arrangements with freight organizations.[3] The usual timeframe of a contract is one year. Apart from the shipment costs wholesalers are affected by weather shocks in producer countries of raw materials. As this is an agricultural product seasonal weather has a large impact on the quantity that could be sold to wholesalers in a given year. Dynamics of supply and demand tells one that

[2] International Tea Committee – Annual Bulletin of Statistics 2009. Page 88.

[3] Interview conducted by the author with an employee of Wollenhaupt GmbH on April 25, 2010, in Vienna, Austria.

this would have an effect on the price of raw tea. However, companies tend to overcome price fluctuations by frame contracts for a given time period.

In the meantime, wholesalers undertake production activities that create value added. These activities are filtering, packaging leaf teas, labeling, flavoring, and tea mixing. All these activities require a set of machinery and other raw materials that are locally acquired. Such are packaging materials, chemicals for flavoring, and paper for labels. As these are locally purchased they are subject to inflation in the given country and overall price movements. These fluctuations are also dealt with supplier contracts. They are minimized by company policy and persistence in the prices of raw materials is present in the industry. For wholesalers, inventory management in this sector is essential to meet consumer demand and orders and to minimize costs. As there is a large delivery lag in receiving raw tea production is based on projections of demand for approximately six months.

Consumer demand is highly volatile across countries and in time. In the time dimension it is dependent on prices, weather conditions and trends in behavior. This last aspect is hard to grasp in terms of models and this study will not deal with it in detail due to the lack of sufficient data. An example on the Hungarian market occurred in 2007, when after a publication in Paramedica newsletter in June orders for Java OP black tea increased substantially until the end of the calendar year.[4] Based on the calculations of this company based in Budapest, in 2007 sales of Java OP black jumped to 118 kg from a mere 20 kg in 2006. The underlying article suggested that black tea harvested on the island of Java had a beneficial effect to the body by lowering the risks of cancer.[5] Prices consumers face are more persistent than the acquisition prices. Prices are

[4] Interview conducted by the author with the CEO of the tea wholesale company Possibilis Kft on May 20, 2010, in Budapest, Hungary.

[5] Ibid.

determined on the basis of costs of production (including the acquisition of raw materials) and a profit margin. The profit margins are usually large. Retail prices of this Hungarian company from which I was able to collect data from include a margin 100 to 300 percent on its products that include 340 different types of teas. Based on prices collected from an array of retail stores in Budapest I have compared prices and concluded that they are tuned together.[6] For the high margin there are two reasons. One is that only a small quantity of tea can be bought. One tea filter contains not more than 2 grams of tea and even in specialty stores 50 and 100 gram packages are the standards.[7] The second reason is that it enables retailers to endure idiosyncratic and economy wide shocks without price adjustments upwards and this enables to maintain their customer base in the long run. Lastly, the weather-based seasonality is an important factor of demand each year in some countries. It has been a convention among tea wholesalers that they publish new prices for the upcoming twelve months in August.[8] Demand for tea is peaking during the winter months. This is due to the fact that in most cultures that are located in the continental climate stripes tea is a winter beverage. It is served warm and has beneficial effects to one’s health. Its most commonly known feature is that it strengthens the immune system of the human body when a bacterial or viral infection surfaces. It contains antioxidants, minerals and teine[9] that together have a cleaning effect on the digestive and cardiovascular system. Furthermore, in December, Christmas has an effect on sales. High quality tea often serves the purpose of a gift either in itself or as a supplement to kitchen accessories such as tea kits or containers, mugs and porcelain items.

[6] Interview conducted by the author with the CEO of the tea wholesale company Possibilis Kft on May 20, 2010, in Budapest, Hungary.

[7] Ibid.

[8] Interview conducted by the author with an employee of Wollenhaupt GmbH on April 25, 2010, in Vienna, Austria.

[9] Teine is a organic substance that has a similar effect on the body as caffeine. The underlying molecule is identical.

Despite the above mentioned factors in prices, seasonality and cultural/health trends there is an income effect that must be noted in terms of consumer demand. Large aggregate systemic shocks to an economy, such as the recent financial crisis, have an effect on the income of consumers. As in the case of Hungary wages have not been able to follow inflation in all sectors and employment security diminished. More of one's income is going towards savings and less to consumption. Even within consumption funds available are drawn away from luxury and expensive items that are not necessities. Tea as I have implied it before have features of a luxury item. There are cheaper substitutes available in terms of its effects. Coffee and instant warm drinks are the most significant ones. In the underlying tea company in Hungary a significant drop occurred in all type of tea sales.[10] A counteracting factor on the aggregate level could be that cheaper and lower quality tea product sales increased.

Overall, the industry in its structural set up is not a complicated one, however, the factors of supply and demand are heterogeneous. Consumer demand is volatile, which is attributable to idiosyncratic and systemic shocks and prices, which in turn determines production by wholesale companies. In the meantime, the volatility in the supply and price of raw tea is the most important factors that determine corporate policy to match raw materials, production and consumer demand in a timely and efficient manner, which makes the holding of inventories imperative for firms in the industry.

In inventory movements there are two observations and results based on the literature that I am going to evaluate using the data from the tea industry. One is that inventories are proportional to sales. Two, there is a short-run trade-off between inventory investment and sales. These are two statements that I am going to take a closer look at if they are applicable to the tea industry.

[10] Interview conducted by the author with the CEO of the tea wholesale company Possibilis Kft on May 20, 2010, in Budapest, Hungary.

The underlying studies of these findings mostly use firm level panel data to draw conclusions from.[11] My approach is bounded by the aggregate country level data I have available. Therefore, I will test these results at the country level.

The further structure of this study is organized to revisit the above-described facts of inventory movements and if they withhold in the tea industry. In Chapter 1, a model of inventory management will be described based on Bils and Kahn (2000). I will give an introduction to the model and describe its overall results relevant to evaluating the underlying issues. In Chapter 2, two economic frameworks will be presented, which provide the backbone of the underlying estimations and regressions. In Chapter 3, I will introduce the data I have gathered and used for the purposes of this study and for the estimations. In Chapter 4, the results of the regressions and estimations will be presented along with their implications.

[11] The underlying studies that I used to evaluate the two issues after making adjustments to the empirical frameworks they used are: Bils and Kahn (2000) and Choi and Kim (2001).

Chapter 1: A Benchmark Inventory Model

In this Chapter I present a summary of the inventory model by Bils and Kahn (2000) and its conclusions, which serves as a benchmark to compare the empirical findings based on my data with.

As for the second benchmark model I will discuss the structure of Bils and Kahn (2000). The model is built upon micro-foundations. The model of the authors suggest at the firm level that firms' demands for finished good inventories are proportional to their expected sale, however, they remain countercyclical relative to sales during business cycles.[12] The authors reject the explanation for the cyclical nature of inventories that relies upon measured prices and productivity. The countercyclical behavior of inventories as stated above require that during expansionary periods firms exhibit high marginal cost relative to discounted future marginal costs or low price markups giving way to inter-temporal substitution.

The patterns in fluctuations in the level of inventories thus can be explained by interpreting fluctuations in labor productivity as a result of mis-measured cyclical utilization of labor, for which the costs are internalized by the firms.[13] The previous statement is also supported by the findings of others that factors of production are worked more intensely in times of expansion.[14] In the meantime, the underlying model provides a different explanation as well. The model suggests that inventory behavior is primarily driven by countercyclical markups, which have the

[12] Bils and Kahn (2000). Page 27

[13] Ibid. Page 27.

[14] The evidence is supported by the following studies: Burnside, Eichenbaum and Rebelo (1995), Bernanke and Parkinson (1991), Shapiro (1993), Bils and Cho (1994).

effect of changing the target inventory-to-sales ratio of the firm. As inventories are failing to match orders by customers, the price of goods are unable to follow the marginal cost.[15]

The underlying model's results on the aggregate level are the following: a rise in real marginal cost, or equivalently a drop in the markup, directly reduces the value of inventory holdings by reducing the valuation of sales generated by those inventories.[16] Therefore the cyclical behavior of inventory stock is the result of the variations in the target inventory-to-sales ratio over the business cycle due to countercyclical markups.

The firm's problem in this is a profit maximization framework, with a Cobb-Douglas production function and inventory technology that reflects an inventory-to-sales ratio to be independent of scale.[17] This corresponds to a inventories of finished goods being productive in generating larger sales at a given price.[18]

$$\max_{y_t} E_t \left\{ \sum_{i=1}^{\infty} \beta_{t,t+i} \left[p_{t+i} s_{t+i} - C_{t+1}(y_{t+i}; \theta_t; z_t) \right] \right\}$$

subject to

$$a_t = i_t + y_t = a_{t-1} - s_{t-1} + y_t$$

$$y_t = \min \left\{ \frac{q_t}{\lambda}, (\theta_t n_t^{\alpha} l_t^{\upsilon} k_t^{1-\alpha-\upsilon})^{\gamma} \right\}$$

$$s_t = d_t(p_t) a_t^{\phi}$$

In the objective function, *s* and *p* stands for sales and price in period *t*; θ denote a technology shock; and *z* is the vector of input price in period *t*. *C(y)* is the cost of producing the output *y* in period *t*. β is the discount factor at time period *t* for *i* periods ahead. As the authors point out this refers to a nominal discount rate. It is also assumed that when firms choose production in *t* they

[15] Bils and Kahn (2000). Page 10.

[16] Ibid. Page 4.

[17] Ibid. Page 4.

[18] These ideas are from the following studies: Kahn (1987) and Kahn (1992).

know the realizations of the variables θ and z that determine the cost of producing, but not the price or sales in the same period.[19]

The first constraint is a flow constraint of goods available for sale in period t, *a*. This consists of the inventory stock carried forward from the previous time period and the goods produced in period t. The second constraint is a specification of a production function. It entails that goods are produced by using a vector of input materials, *q*, and value-added by a Cobb-Douglas production function of labor, *n*, non-production labor, *l*, and capital, *k*. The parameter γ determines the scale of the value added production function, which is greater than 1 in the specification by the authors. Material inputs are proportional to output as dictated by a vector of per unit material requirements, λ, which in the model is not a choice variable.[20] The third constraint specifies the relationship between finished inventories and sales of the firm. Subject to the price in the given time period, the firm sees its sales as increasing with an elasticity of ϕ with respect to its available stock for sale, where $0 \leq \phi \leq 1$. The intuition behind this is that if the elasticity is equal to 1, then a competitive firm can sell out all its available stock and a stock out phase could occur. On the other hand if the elasticity is 0, then it would mean that production and sales is only subject to cost-smoothing. Inventories in this model are viewed as an aggregate of similar goods of different sizes, colors, locations...etc.[21] Lastly, in the case when the elasticity of the available goods is between 0 and 1 then a larger stock promotes matching with potential buyers, who arrive with preferences for the specific type of good, however, the marginal benefit of inventories diminishes in *a* relative to expected sales.[22] Based on the panel data on US

[19] Bils and Kahn (2000). Page 4.

[20] Ibid. Page 5.

[21] Ibid. Page 5.

[22] Ibid. Page 5.

manufacturing industries by the authors, a trend is spotted that firms hold stocks of finished inventories equivalent of one to three months' worth of sales. Therefore, contrary to the suggestion of the model (i.e. diminishing benefit of large stocks) that firms value inventories beyond their role in varying production relative to sales.[23]

In the model demand for the producer is subject to the sales price of the goods produced, *d(p)*. This allows in a competitive setup that firm demand is determined by total supply and consumer demand. In the absence of perfect competition the firms maximize the objective function with respect to prices as well. This way the model is fit for mimicking a competitive and a monopolistic industry as well.

Overall, the framework of Bils and Kahn is suitable for evaluating the trends of the tea industry. It provides a set up in the absence of trade frictions just as if there were a just-in-time system in place at the firms.

[23] Bils and Kahn (2000). Page 6.

Chapter 2: The Data

For the evaluation of the tea industry the focus will be on the aggregate country level data. I used two sources for country level and trade data. One is a comprehensive database of the International Tea Committee (ITC) based in London.[24] From the ITC I have acquired ten years long time series at the country level on imports/exports, sales/consumption and world prices based on auctions in producing countries. The latter one covers a five-year long period only. Furthermore, there is readily available data on consumption in the database of the Food and Agriculture Organization (FAO) of the United Nations.

There are a number of limitations to the data available. First, the databases are not accessible for the general public. In the case of the FAO only a limited number of queries can be initiated. Regarding the ITC data, it is only made available in the form of publications for a relatively high cost. Furthermore, the data that I have acquired differed in the level of detail compared to what I have desired for. I have used the Annual Bulletin of Statistics (2009) of the International Tea Committee. In the consumption and trade data there were no differentiation among the types of teas. Initially I wished to differentiate between tea products along the major tea types (i.e. black tea, green tea, Rooibush, mate tea and fruit mélanges), however, in the statistical bulletin there was only data on aggregate tea levels and in some instances separately on black and green tea. This fact limited my analysis to an aggregate analysis only.

[24] International Tea Committee – Annual Bulletin of Statistics 2009 is the latest edition of a continuously updated comprehensive collection of data of the tea industry. It focuses on trade (export, imports, re-exports) and consumption.

Another limitation to the data available was the fact that aggregate or firm level inventory stock data was only available for the United Kingdom through the UK Tea Council[25], which is the official regulatory body of the tea industry in the UK. This created a problem that apart from one country I lacked the data on beginning inventory levels. I overcame this obstacle by calculating the ratio of end of period inventory to consumption, which was 2.69. This means that at the end of the first period inventories were 2.69 times larger than the consumption for that period. Furthermore, I made the assumption that this ratio was representative of the countries in my sample. Therefore, I calculated the first end of period inventory levels by multiplying the consumption in that period by 2.69. The first beginning of period inventories I calculated by subtracting the consumption in the first period from the end of period inventories for all countries.

There are 15 countries in the dataset I used that are all importing and consumer countries of tea. In reality, some of these countries re-export tea after adding some value added to it, however, I omitted re-exports. The reason for the omission was that the underlying empirical models I intend to use do not allow for re-exports. As the countries are not harvesting ones, they import the majority of tea for consumption. The countries included in the sample are the following:

1 - Austria
2 - Czech Republic
3 - Denmark
4 - Finland
5 - France
6 - Germany
7 - Ireland
8 - Italy
9 - The Netherlands
10 - Norway

[25] The data was available only through the International Tea Committee.

11 - Poland
12 - Switzerland
13 - Canada
14 - U.S.
15 - United Kingdom

The available data included 10 years long monthly frequency time series of sales and imports for the above listed countries only. Time series of sales and imports for consumption provided the basis for calculating the corresponding beginning and ending of period series provided the initial calculations mentioned above for the starting values of inventories. The assumption that the ratio of consumption to inventories in the UK is representative of the sample countries is based on the notion that most of them are a part of the developed world based on their income in 1998 in current international dollars based on PPP:[26]

Table 1 - GDP per Capita of Selected Countries in 1998

Country	GDP per capita (current int'l dollars – PPP)
Austria	25,959
Canada	25,608
Czech Republic	13,777
Denmark	25,964
Finland	21,630
France	23,613
Germany	24,216
Ireland	23,588
Italy	22,526
Netherlands	26,815

[26] IMF - World Economic Outlook Database April, 2010 - GDP based on purchasing power parity per capita in current international dollars.

Norway	36,290
Poland	9,073
Switzerland	28,826
United Kingdom	23,251
United States	31,858

The outliers in the group are Poland and the Czech Republic with substantially lower per capita income. However, it can be seen that over the course of ten years these countries have been able to close up on the gap somewhat. There are two more outliers but in the opposite direction. Norway and the United States have significantly higher GDP per capita than the average of the group at 24,200 dollars. However, my initial assumption is reasonable based on the cultural feature of these two countries that none of them are culturally prone to consume tea.

Table 2 displays the summary of the descriptive statistics of the main variables in level terms (log terms). From this it can be concluded that the level of inventories is more volatile than the levels of sales across countries and time. The same can be determined from the standard deviations of the growth rates (log difference variables), namely, the growth rate of inventories is more volatile than the growth rate of sales. The inventory-to-sales ratio has a mean of 3.54 across the sample.

Table 2 - Descriptive Statistics 1.

	N (no. of obs.)	Mean	Standard Deviation	Median
ln S(i,t)	1800	6.4217	1.5339	6.4134
Inv (i,t)/S(i,t)	1800	3.5417	3.2171	2.8934
ln Inv(i,t)	1800	7.3474	2.0603	7.7943
dln S(i,t)	1785	0.000567	0.1007	-0.00868
dln Inv(i,t)	1683	-0.001056	0.2366	0.00134

The above data and methods to construct series of inventories for the beginning and end of period are used in framework of Part A of Chapter 3. However, the time series across countries are also used to estimate the demand equation for tea across countries based on a simple model of Part B of Chapter 3.

For the purposes estimation I use the time series of sales across countries directly in the empirical evaluations, meanwhile, import data is only used to construct a beginning of period inventory measure. For this I used the previously determined ratio of UK end of period inventories relative to sales in the same period. Then I multiplied the first month sales figure by this number (2.69) and added the actual sales and subtracted the import numbers to get inventory figures for the beginning of the first month, which happens to be January of 1998. After that I constructed beginning of period inventory series for each country by adding imports and subtracting exports from beginning inventory stocks to get the next period beginning inventory stock. This is line with the model's inventory stock flow constraint in Chapter 3 part (B):

$$a_{i,t+1} = a_{i,t} - s_{i,t} + m_{i,t}$$

Furthermore, the ITC Annual Bulletin of Statistics contained monthly average prices of all tea types from the major auction markets in the world. These included Chittagong, Colombo, Jakarta, Mombasa, Limbe, Kolkata and Guwahati. I chose the prices from the Jakarta auction market as trading is done in US dollars and the turnover in trade quantity is among the top three auction markets in my sample of auctions. The time series of prices begin in January 2005 and end in December 2008, which are 48 observations. Therefore, I used equivalently 48 observations from other series (sales, beginning of inventory stock) for the same time period to be consistent.

From the statistical summary below one can grasp that inventories are the most volatile with standard deviation of 9132 tons. Also, the average monthly level of inventory is approximately three times larger than that of sales in the period. Prices are the least volatile.

Table 3 - Descriptive Statistics 2.

	Mean	Median	Standard Deviation
Sales	1983	657	3296
Beginning of Period Inventory	6389	2813	9132
Acquisition Price of 1 ton of Tea	1309	1340	205

Finally, from the serial correlation matrix one can see that sales and inventory stocks are relatively highly correlated; meanwhile, prices are lowly correlated with sales and inventory stocks. Hereby it must be noted that the data for global prices is a rough proxy of actual ones. As described in the introduction it is only related to a ton of tea and shipment costs are, for instance are assumed away for further analysis.

Table 4 - Serial Correlation Matrix

	Sales	Beginning of Period Inventory	Acquisition Prices
Sales	1.0000		
Beginning of Period Inventory	0.8732	1.0000	
Acquisition Prices	-0.0036	-0.0031	1.0000

In summary, I used the same monthly ten years long country level series for all of my further estimations. There is difference in the calculation of the inventory stock series for beginning and ending of each period that are in line with the respective frameworks in the following chapter. Furthermore, in the latter case the time series across countries were only 48 periods long instead of 120 due to the limitations of available price data.

Chapter 3: Empirical Setup

In this Chapter I will present two frameworks for testing the implied relationships based on the model in Chapter 1. The first framework is aimed at evaluating the determinants of inventory levels, meanwhile, in the second part of this Chapter I present a simple partial equilibrium model of a representative firm through which I intend to evaluate the determinants of the demand for tea.

Part A

In the following framework the demand for inventories is determined by a number of motives. First, there are the motives of avoiding a stock-out, smoothing production and meeting orders. The latter as it has been established in the introduction is the one most important determinant of inventory demand. Inventories comprise of goods and raw materials for production. Here I must make a simplification as a result of the feature of production in the tea industry. The raw material is equivalent in quantity to the finished good. There is mostly only value added production in the form of flavoring and packaging. As in terms of quantity raw materials and finished goods are equal. I further assume that other raw materials are negligible in terms of quantity and costs. Based on this, I make the assumption that in each period, production equals raw materials in quantity. The only major difference is in the price of acquiring the raw tea and the sales price.

As for the framework, I assume that the representative firm chooses inputs, including inventories at the beginning of each time period. In the beginning of each period the firm also chooses its level of production. Furthermore, the firm chooses the inventory investment outright at the start of the period. It should be noted that in this framework there are no delivery lags.

Total output therefore corresponds with the sum of inventory investment and the output of finished goods, which are equal in quantity.

$Y_{i,t}$ - represents the output of the representative firm. This means, for example, in the case of the tea industry that if a firm orders 100 tons of raw tea, then the output in that period will be a 100 tons of tea available for sale, packaged and flavored. Here it does not make sense to mark inventory investment as a different variable from output unlike in the case of delivery lags. Production function is homogeneous of degree one where the quantities of output and input linearly related.

$Inv_{i,t-1}$ - marks the quantity of inventory carried forward from the previous period. In the framework it is also not reasonable to distinguish between inventories of raw materials and finished goods as result of the nature of the production technology that is also in line with our assumptions. This variable is also measured in tons of tea.

${}^{*}Inv_{i,t}$ - stands for the beginning of period inventory of tea measured in tons. It equals the inventories carried forward from the previous period plus inventory investment, which equals output.

$${}^{*}Inv_{i,t} = Inv_{i,t-1} + Y_{i,t}$$

$S_{i,t}$ - is the total sales of tea in a given period. It is measured in tons.

$Inv_{i,t}$ - this variable marks the end of period inventory in tons of tea. It equals the beginning of period inventory minus sales.

$$Inv_{i,t} = Inv_{i,t-1} + Y_{i,t} - S_{i,t}$$

Altogether planned inventory investment is made up of outright investment (output) in each period less sales. Also, in line with Choi and Kim (2001) and Bils and Kahn (2000) it can be stated that output should respond more than proportionately to sales.

Now let us turn to the empirical model specification. In the above framework it has been laid down that sales have a positive relationship with inventory levels. First, I am going to take a look at this relationship with a simple panel regression with inventories as the dependent variable and sales as the independent variable.

$$\ln Inv_{i,t} = \alpha_t + \beta \ln S_{i,t} + e_{i,t}$$

There is also a time varying parameter in α_t that could cover and reflect the effects and changes in inventory management over time. Furthermore, it is easy to see, as it has been implied by Bils and Kahn (2000), that if the inventory-to-sales ratio is stable across time, then β should equal 1.[27]

As a further step, I am specifying a more complex inventory adjustment model. In this regression the dependent variable is the change in the level of inventories. Regarding the explanatory variables, since the previous regression implies that firms manage and implement changes in inventories to close the gap between the target inventory-to-sales ratio and the actual one, I have included a lagged version of the inventory-to-sales ratio on the right hand side. Among the explanatory variables there is the change in the real inventory stock and that of sales.

$$\Delta \ln Inv_{i,t} = \beta_1 \Delta \ln Inv_{i,t-1} + \beta_2 \ln(Inv_{i,t-1} / S_{i,t-1}) + \beta_3 \Delta \ln S_{i,t} + \beta_4 \Delta \ln S_{i,t-1} + \theta_t + w_{i,t}$$

[27] Based on Choi and Kim (2001) page 7.

The coefficient of the lagged inventory-to-sales ratio is expected to be negative because if there is a target ratio and there is a rise in the actual one then a negative adjustment follows in the next period. This is implied by the notion that firms in the industry are maintaining a stable ratio.

Now turning to movements in sales, with an unexpected jump in sales inventories would adjust downwards. This would be a result of the role of inventories as a buffer stock, i.e. counteracting a sales shock. The lagged sales growth may have a negative coefficient as well, as a result of the time firms need to adjust inventories through changing raw material orders and production.

Part B

As the next step I introduce another simple framework to assess the relationship of inventories to sales and acquisition prices. This is a simple model resembles the features of the partial equilibrium model setup of Bils and Kahn (2000) by focusing solely on the representative firm's problem. In this model the representative firm could be viewed as one large firm representing a country. The firm maximizes profits subject to a production and an inventory technology. My overall goal is to estimate a demand function that is subject to inventory stocks and global prices to get a deeper insight into the relationship of sales and inventories.

The firm has a production function that is homogeneous of degree one and output and imports, which represent the only input into production, are linearly related. This means as in the previous case that one unit of output is gained from one unit of input, which is in our case, is one ton of raw tea. The objective function and maximization problem looks as the following:

$$\max_{p_{i,t}, s_{i,t}, m_{i,t}, a_{i,t}} E_t \left[\sum_{T=0}^{\infty} \beta^T \left(p_{i,t+T} s_{i,t+T} - z_{i,t+T} m_{i,t+T} \right) - \delta a_{i,t} \right]$$

subject to

$$s_{i,t} = A\theta_{i,t} p_{i,t}^{-\varepsilon} a_{i,t}^{\phi}$$

$$a_{i,t+1} = a_{i,t} - s_{i,t} + m_{i,t}$$

In the objective function $p_{i,t}$ and $s_{i,t}$ represent sales prices and sales respectively, meanwhile, z_t is the acquisition price of the input $m_{i,t}$. The acquisition price is based on global prices from the auction in Jakarta. I chose the Jakarta tea auction market because the currency of trading is the US dollar and by turnover of trading it is among the top three auctions in the world. Due to the fact that I assume that firms acquire inputs on global prices there are no cross-country differences in this cost. The firm also has to endure a each period a fixed cost of storage cost that is always a fixed portion, δ, of the inventories, $a_{i,t}$, in the beginning of the period. The firm therefore makes sales at a given price in each period to generate revenues, meanwhile, endures the acquisition costs of inputs and a fixed cost of production.

The first constraint determines the demand for the product of the company, which is in our industry case, is tea. The demand is depending on inventories and the sales price. For a given price, a producer views its sales as increasing with an elasticity of ϕ with respect to its available stock, where $0 \leq \phi \leq 1$.[28] This parameter's role is identical to that in the original model of Bils and Kahn (2000). It allows in a competitive case for stock-outs at one extreme when the elasticity is equal to one. On the other extreme case when the elasticity is equal to 0 it represents a case of a pure cost-smoothing model. When the elasticity is in between zero and one then larger inventory stock promotes matching of products with buyers with given preferences, which

[28] Bils and Kahn (2000). Page 5.

entails that the marginal benefit of this matching process diminishes in the inventory levels relative to sales.[29]

As pointed in the previous description of the data available in the UK in January of 1998 held 2.69 times more inventories in the end of the month than the actual sales of tea in the same month. This is in line with the findings and data of Bils and Kahn (2000), who suggest that typically firms hold stocks of finished inventories that are equivalent of one to three months' worth of sales.[30]

The demand for tea moves proportionately with a stochastic function of $d_{i,t}(p_{i,t}) = A\theta_{i,t} p_{i,t}^{-\varepsilon}$, where A is a scale parameter, $\theta_{i,t}$ is stochastic demand shock, which I assume to be an i.i.d. process for the sake of simplicity. Furthermore the parameter ε captures price elasticity, which is identical across countries.

The second constraint is a simple flow equation that determines the next period's beginning inventories. The beginning inventory is determined by the beginning inventory in the current period plus inventory investment (acquisition of inputs in this case) from which we subtract the sales in the current period.

After describing the setup of the model one can derive the first order conditions. The first order conditions are the following:

$$(1)\ s_{i,t} = \lambda_{i,t}\varepsilon \frac{s_{i,t}}{p_{i,t}} \quad \rightarrow \quad p_{i,t} = \lambda_{i,t}\varepsilon$$

$$(2)\ \mu_{i,t} = z_t$$

$$(3)\ p_{i,t} - z_t = \lambda_{i,t}$$

$$(4)\ \mu_{i,t} = E_t(\mu_{i,t+1}) - \beta\delta + E_t\left[\lambda_{i,t+1}\phi \frac{s_{i,t+1}}{a_{i,t+1}}\right]$$

[29] Bils and Kahn (2000). Page 5.

[30] Ibid. Page 5.

From the first order conditions we can see that after differentiating with the control variables import term falls out. Combining equations (1), (2) and (3) and some straightforward manipulations we can derive the constant markup over the acquisition price from which we make the assumption that firms across countries charge a constant markup over the acquisition cost of inputs. This is enabled by our simple production technology. The markup is the following:

$$(5)\ p_{i,t} = \frac{\varepsilon}{\varepsilon - 1} z_t = p_t$$

As input prices are identical to firms in all countries and there is a constant markup policy in determining sales prices we can conclude that sales prices in this model are the same across countries and it only differs across time. Now let us denote the markup by capital *M*. Now, using equation (1), (2) and (5) we can derive an equation that determines the inter-temporal substitution of holding inventories.

$$(6)\ E_t \left\{ \left[1 + \frac{\phi}{\varepsilon - 1} \frac{s_{i,t+1}}{a_{i,t+1}} \right] z_{t+1} \right\} = \beta\delta + z_t$$

This equation tells us that cost of holding one extra unit of inventory equals the present value of the fixed cost of holding one unit of inventory and the acquisition cost, which is equal the benefit of it in the next period that is coming from sales.

After laying down the optimality conditions for the firm now we can turn turn to estimating the demand for the underlying good of the firm. We derive the final equation that is to be estimated by substituting (5) into the demand equation and then taking the natural logarithm of both sides. This way we get the following logarithmic demand equation:

$$(7)\ \ln s_{i,t} = \ln\theta_{i,t} + \ln A_{i,t} - \varepsilon \ln M_t - \varepsilon \ln z_t + \phi \ln a_{i,t}$$

This is the demand equation that I will estimate. On the left hand side there is the level of sales, which is dependent on a sales/demand shock, $\theta_{i,t}$, with an expected value of 0 as it is an i.i.d. process across countries; a constant term, $\ln A_{i,t} - \varepsilon \ln M_t$, that accounts for the cross-sectional fixed effects across time; and the level of prices and inventories in the same time period. As the expected value of the sales/demand shock is zero the final model specification will be the following:

$$(8)\ \ln s_{i,t} = (\ln A_{i,t} - \varepsilon \ln M_t) - \varepsilon \ln z_t + \phi \ln a_{i,t}$$

In line with my model and that of Bils and Kahn (2000) I expect that the relationship between levels of sales and inventories will be positive but less than proportional, meaning, that the coefficient ϕ remains between 0 and 1, which would reflect a diminishing marginal benefit from holding inventories. This would also provide evidence for a sluggish co-movement of sales with increasing inventories. As for the price elasticity of input prices I expect it to be larger than unity based on the assumption that tea is a normal good and there is a constant markup determined by the price elasticity.

Chapter 4: Estimations and Results

In this Chapter I will report the results of the regressions and interpret them in the light of my expectations and the results of the benchmark model of Bils and Kahn (2000). In addition, I will discuss qualitatively the differences in the outcomes of the regressions compared to the models.

Part A

It is the aim of my first regression to determine if there is a close link between the levels of inventories and sales, as it has been suggested by the target inventory benchmark model of Chapter 3. I performed the regression first by using a pooled OLS method and fixed effect estimation method. The results are presented in the table below.

Table 5 - OLS and 2SLS

	Pooled OLS	2SLS
Constant	0.1221 (0.6933)	-0.00518 (0.7614)
lnSales	1.1190 (0.0892)	1.1323 (0.0954)
R-squared	0.70	0.68
N	1719	1539

Results of the pooled OLS regression confirm the expected relationship between the levels of sales and inventories. The adjusted R^2 is 0.70 and the estimated coefficient of the level of sales is close to unity. The coefficient for sales is significant at the 5 percent significance level. These results are in support of the relationship between sales and inventories that suggests that firms at a country level hold inventories roughly proportional to sales over time.

For the purpose of robustness check I have estimated the inventory-sales relationship with a two stage least squares method to control for the possible biases that could arise from the correlation of the regressor and the error term. This scenario could arise if the firms of a country in the sample would target expected sales instead of using actual sales as in our case. To control for such a bias with 2SLS method using the 12 lags of the explanatory variable as instruments. This way as it can be observed from the above table that this method yields almost the same results with a coefficient for the level of sales above one, meanwhile, being statistically significant. The R-squared is 0.68, which is close to the result of the pooled OLS result of 0.70. Based on the results of these two regression it can be established that firms in these countries more or less keep inventories roughly proportional to sales in the tea industry. This evidence is in line with the findings Bils and Kahn (2000) and Choi and Kim (2001) on durable good producing industries and S n P 500 firms.

In the specification of the regression for dynamic adjustment of inventories is specified in the difference of the levels of inventories. In this I have ran the regressions to determine the effect of sales growth. Furthermore, I have looked at the effects of inventory investment and the inventory-to-sales ratio. I used fixed effect estimation method once without adding time dummies and including them as well.

With regards to the sales growth effect on inventory investment there are somewhat different results. In case when there are no dummies in the specification the current period sales growth reduces inventory investment, meanwhile, the one period lagged one increases. In case of both variables the results are statistically significant at the 5 percent level. At the same time, when the time dummies are included in the regression and accounting for the country level fixed cross-section effects across time, then both the current and the lagged coefficient of the sales growth are negative, which would be in support of the role of inventories as a buffer stock. In other words this would provide evidence for the production-smoothing role. However, it must be noted that only the coefficient of the current sales growth is statistically significant.

In both specifications the lagged dependent variable on the right hand side has a positive coefficient 0.19 and 0.21 respectively. Both are statistically significant which suggests that over time there is no adjustment with oscillation as in the findings of Choi and Kim (2001). This means that if previous period inventory growth is larger by one unit then current period inventory growth will be larger by 0.2 approximately ceteris paribus. The coefficient of the lagged inventory-to-sales ratio is in both cases is negative but statistically not significant. The negative coefficients in themselves would provide evidence in support of inventory adjustment in line with inventory-to-sales targeting.

Table 6 - Fixed Effect Estimation of Dynamic Setup

	Fixed Effect w/o Time Dummies	Fixed Effect with Time Dummies
Constant	0.0254 (0.0284)	0.0929 (0.0569)
ld_Sales	-0.3581 (0.0960)	-0.6608 (0.3777)
ld_Sales_1	-0.1827 (0.0463)	-0.1140 (0.2845)
l_InvSalesR_1	0.0320 (0.0285)	-0.0247 (0.0248)
l_Inv_end_1	0.1944 (0.0870)	0.2089 (0.0813)
N	1656	1656
Adjusted R-square	0.0820	0.1432

In summary, using the data from the ITC database for the static empirical model based on the first framework found evidence for a positive close to proportional (a bit more) relationship between the levels of sales and inventories. This is in support of the findings of Bils and Kahn (2000). Therefore, in the tea industry on the aggregate level inventories move proportionally to actual sales. In the meantime, based on the dynamic empirical model specification the inventory-to-stock ratio shows a positive relationship with inventory growth in the tea industry, which would provide evidence against adjustments with oscillations as in Choi and Kim (2001), however, the results are not conclusive as they fail to be statistically significant.

Part B

Based on the simple model of Chapter 4 part (B) here I will estimate the parameters of the demand equation as specified by equation (8) for the tea industry:

$$(8)\ \ln s_{i,t} = (\ln A_{i,t} - \varepsilon \ln M_t) - \varepsilon \ln z_t + \phi \ln a_{i,t} + u_{i,t}$$

The data is 48 observations per variable for 15 countries. The dependent variable is the level of sales. The constant term accounts for any cross sectional fixed effects across time, meanwhile, the explanatory variables are the levels of inventories and the global price level of tea. I estimated the parameters with pooled OLS regression and fixed effect panel method for which the results are summarized in the table below.

Table 7 - Demand Equation Estimation

	Pooled OLS	Fixed Effect Estimator
Constant	1.1089 (1.9542)	6.3075 (4593)
z(t)	0.0505 (0.1936)	-0.0117 (0.0555)
a(i,t)	0.6679 (0.1073)	0.05048 (0.0121)
N	605	605
Adjusted R-squared	0.7439	0.989261

In both estimations the coefficient of the level of inventory levels is positive and between zero and one, which is in line with our expectations. With both methods the results are significant at the 5 percent level. This indicates to the fact that based on the original benchmark model inventories in the tea industry are not solely used as a buffer stock but also to gain the marginal benefit of matching buyers preferences.

However, the results of the two estimation methods differ greatly in terms of the coefficient of the level of global prices (which represents the price elasticity as well). In case of the pooled OLS the coefficient is positive, meanwhile, statistically not significant. This would mean that by 1 percent increase in the global acquisition price of raw tea sales level would increase by 0.05 percent. Even though it is close to zero there would still be an attenuation bias upwards stemming from the fact that the Jakarta monthly average prices are very rough proxies of actual global prices. In the meantime, the fixed effect method estimated a negative coefficient, however, it remained below unity, which fails to meet expectations. The estimate of the price coefficient is also fails to be significant statistically. Again the inconsistency of the estimation method can be a result of attenuation bias in this case as well and that is why this coefficient has been underestimated.

In comparison the fixed effect estimation method had a higher explanatory value with an adjusted R-square value of 0.98, meanwhile, the pooled OLS performed reasonably as well with an R-square value of 0.74. Overall, the fixed effect estimator performed better than pooled OLS.

In conclusion, I could not confirm all the implications of my simple model on consumer demand. The results of both estimation methods indicated that the relationship between the level of sales and level of inventories is withstanding and significant statistically. This means that in the tea industry inventories serve different purposes at the same time such as a buffer stock role and enabling the firm to meet consumer preferences and by that gaining the marginal benefit of storing an extra unit of it, however, as the below unity coefficients may indicate there is a diminishing marginal benefit over having an extra unit stored. In the meantime, the results on the coefficient of the global prices are mixed. The fixed effect estimator performed clearly better but failed to meet the expectations based on the simple model. In any case, both of the fixed effect method and the pooled OLS was inconsistent. Based on reviewing the literature and similar studies I have come to the conclusion that based on my studies I lacked the technical knowledge to perform a more sophisticated estimation method such as the GMM, which has also been used by Bils and Kahn (2000) to estimate their model parameters. A further limitation to perform more accurate and consistent estimates was that especially in terms of prices the data available for use was very rough and possibly not fully representative of global tea prices on average.

Conclusion

In conclusion, this thesis attempted at determining if two statements are applicable to the tea industry with regards to inventory movements. One was the statement that inventories are proportional to sales; meanwhile, the other tried to grasp a short-run trade-off between inventory investment and sales.

The simple inventory flow approach with a modified empirical setup of Choi and Kim (2001) provided evidence that the level of sales have a positive proportional relationship to the level of inventory on an aggregate level. A dynamic setup based on the same approach, however, yielded somewhat mixed results. The inventory-to-stock ratio showed a positive, but statistically not significant, relationship with inventory growth in the tea industry. Therefore, I could not draw definite conclusion regarding the second statement. The estimation results did not confirm the initial statement on the trade-off between inventory investment and sales.

To further analyze the relationship of inventories to sales I have developed a simple partial equilibrium model based on the model of Bils and Kahn (2000). The model of the paper is simply put a modified version of the original model. Here I intended to take a look at the relationship of inventory stock and sales through estimating a demand equation. In this model a constant mark-up was on sales prices and they depended on input prices only due to the linear production technology, which was HOD 1. The results were mixed here as well. The estimation by fixed effect and pooled OLS methods confirmed that the level of inventory had a positive relationship with sales demand; however, it did not confirm a proportional relationship. In terms of acquisition prices, only one estimation method gave a negative relationship, but it was not statistically significant. Overall, both approaches provided some evidence in support of the two statements, but failed to confirm the proposed relationships without doubt.

In this part of the thesis I would like to summarize the issues that arose during the research and might have an effect on the end result. First of all, I would like to mention the problem of lack of data. There has only been aggregate country level data available through the International Tea Committee and the Food and Agriculture Organization of the UN. Furthermore, price data has only been available from tea auction markets and not from other representative sources. These issues limited my evaluation and likely yielded a bias in the data and thus in the estimations. A technical issue arose when I chose the estimation methods. The lack of knowledge of advanced econometrics limited the list of possible estimation methods and as a result I could not implement GMM estimation in the case of the demand equation estimation as in the study of Bils and Kahn (2000).

Finally, I would like to share my thoughts on how this research could be brought forward. A first possibility would be to acquire firm level data. I have attempted to get data from the wholesale company Wollenhaupt GmbH, but for understandable reasons I have been turned down. Firm level data would enable to get a more accurate picture of inventory movements in the tea industry. Following from the previous point a more complex production function and a more detailed pricing mechanism could be estimated, which would enable more accurate results. The relevance of the tea industry lies in the fact that it is an agricultural product and is subject to a vast number of threats during storage and shipment. Like in Alessandria et al. (2008) the introduction of delivery lags and shipment costs could further clarify the picture. What is the relationship if inventory levels and sales given the proposed tracks for further research be it in the form of the introduction of frictions or better quality data.

List of Tables

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APPENDIX: Regression Reports

Model 8: Fixed-effects, using 1656 observations
Included 15 cross-sectional units
Time-series length: minimum 80, maximum 118
Dependent variable: ld_Inv_end
Robust (HAC) standard errors

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	0.0254299	0.0284577	0.8936	0.37166	
l_InvSalesR_1	-0.0320356	0.0284779	-1.1249	0.26078	
ld_Sales	-0.358112	0.0960152	-3.7297	0.00020	***
ld_Sales_1	0.182745	0.0462946	3.9474	0.00008	***
ld_Inv_end_1	0.194422	0.08703	2.2340	0.02562	**

Mean dependent var	-0.004980		S.D. dependent var	0.193626
Sum squared resid	56.33779		S.E. of regression	0.185514
R-squared	0.092027		Adjusted R-squared	0.082043
F(18, 1637)	9.217622		P-value(F)	1.43e-24
Log-likelihood	449.5358		Akaike criterion	-861.0716
Schwarz criterion	-758.2406		Hannan-Quinn	-822.9530
rho	0.470585		Durbin-Watson	1.011280

Test for differing group intercepts -
Null hypothesis: The groups have a common intercept
Test statistic: F(14, 1637) = 2.51119
with p-value = P(F(14, 1637) > 2.51119) = 0.00151495

Model 4: Fixed-effects, using 1656 observations
Included 15 cross-sectional units

Time-series length: minimum 80, maximum 118
Dependent variable: ld_Inv_end
Robust (HAC) standard errors

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	0.0254299	0.0284577	0.8936	0.37166	
ld_Sales	-0.358112	0.0960152	-3.7297	0.00020	***
ld_Sales_1	0.182745	0.0462946	3.9474	0.00008	***
l_INVSALES_1	-0.0320356	0.0284779	-1.1249	0.26078	
ld_Inv_end_1	0.194422	0.08703	2.2340	0.02562	**

Mean dependent var	-0.004980		S.D. dependent var	0.193626
Sum squared resid	56.33779		S.E. of regression	0.185514
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Log-likelihood	449.5358		Akaike criterion	-861.0716
Schwarz criterion	-758.2406		Hannan-Quinn	-822.9530
rho	0.470585		Durbin-Watson	1.011280

Test for differing group intercepts -
Null hypothesis: The groups have a common intercept
Test statistic: F(14, 1637) = 2.51119
with p-value = P(F(14, 1637) > 2.51119) = 0.00151495

Model 21: Fixed-effects estimates using 605 observations
Included 14 cross-sectional units

Time-series length: minimum 3, maximum 48
Dependent variable: l_s_t_
Robust (HAC) standard errors

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	6.30756	0.459369	13.7309	<0.00001	***
l_Z_t_	-0.0117109	0.0555377	-0.2109	0.83307	
l_A_t_	0.05048	0.0121196	4.1651	0.00004	***

Mean dependent var	6.612118		S.D. dependent var	1.589831
Sum squared resid	15.98754		S.E. of regression	0.164753
R-squared	0.989528		Adjusted R-squared	0.989261
F(15, 589)	3710.300		P-value(F)	0.000000
Log-likelihood	240.6513		Akaike criterion	-449.3026
Schwarz criterion	-378.8189		Hannan-Quinn	-421.8749
rho	0.813839		Durbin-Watson	0.373543

Test for differing group intercepts -
Null hypothesis: The groups have a common intercept
Test statistic: F(13, 589) = 1058.83
with p-value = P(F(13, 589) > 1058.83) = 0