Retail Dynamics and Trade Elasticity Puzzle

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Abstract

This paper studies the role played by the dynamics of retail capacity in determining exchange rate pass through (ERPT) and trade elasticity. As shown by Corsetti and Dedola (2005), local cost components in the form of distribution may contribute to explaining incomplete pass through, as they tend to make the trade elasticity depend on the relative distribution margin. I model distribution as an investment in retail capacity, inducing a difference between short and long run demand elasticities. The slow adjustment of retail capacity offers a possible explanation for the "international elasticity puzzle". The model can generate a high (4-5) long-run trade elasticity without conflicting with a low (0.5-1) short-run elasticity.

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1 Introduction

Two important puzzles have been shaping the debate in open macro in recent years. One is the so-called elasticity puzzle: macro and short-run estimates tend to show that trade elasticities are very low.[1] The other one concerns the determinants of the local currency price stability of imports, i.e., the low degree of exchange rate pass through. In this paper, I underline the importance of the dynamics of retail capacity for understanding exchange rate pass through and trade elasticity and show how these two puzzles can be explained in a unified framework.

This paper builds on Corsetti and Dedola (2005) and models the local component as the result of optimal investment decisions on building local retail networks. I consider a market structure with three types of producers and a single type of distributing firms. The first type of producers, denoted as "retailing manufacturers", sell directly to home and foreign consumers by building their own local retail networks. The second type of producers, denoted as "non-retailing manufacturers", sell their products to local retailers. The third type of producers specialise in local nontradable goods and no distribution is needed. Local distributors, denoted as "local retailers", buy a range of home and foreign tradable goods, set the retail price for each product and adjust their investment in retail networks according to all products they sell.

The perceived demand elasticity is firm-specific, depending on a firm's share of retail networks. A larger share enables the firm to access a larger consumer base, reduce its per unit distribution cost and lower its distribution margin. By selling to local retailers, non-retailing manufacturers benefit from the large retail network accumulated by local retailers at the cost of the additional markup charged by local retailers. Non-retailing manufacturers are not in control of the retail network. They price their products taking decisions made by local retailers as given, resulting in a high ERPT. Retailing manufacturers internalise their investments of retail networks. These firms have two means to boost their sales. At the equilibrium, they trade off between a more costly method which leads to a long run gain in sales by investing in their retail networks and a less costly method by temporarily cutting their prices. At their optimal choice, ERPT is relatively low compared to that for non-retailing manufacturers. Aggregate ERPT and trade elasticity depend on firms' share of retail networks and the corresponding vertical market structure. In this aspect, my model contributes to the literature on how vertical or horizontal market structures affect prices

[1] The quantitative analyses of international real business cycle models and international trade models have made significant progress over the last two decades. Nonetheless, the trade literature [e.g. Eaton and Kortum (2002) and Alvarez and Lucas (2007)] needs to set a high **?** elasticity of substitution between imports and home produced tradable goods to capture the long-run adjustment of intensive and extensive margins. In contrast, international real business cycle models, Backus, Kehoe and Kydland (1994) and Heathcote and Perri (2002) for example, need a small elasticity to generate observed volatility of terms of trade and the negative correlation between trade balance and terms of trade. This tension is referred to as the "international elasticity puzzle"(see Ruhl (2008)).

and ERPT[2] by adding a novel aspect on how firms compete for retail resources.

The difference between short-run and long-run trade elasticities can be explained through two channels. The first channel is similar to the mechanism of Drozd and Nosal (2012)[3] where changes in consumption are restricted by the firm's retail capacity in the short run, and trade elasticity goes up as this restriction is released gradually in the long run. All quantity adjustments are driven by price changes in the short run, while in the long run the retail capacity extends gradually and the relative consumption shifts more. In the second channel, changes in retail capacity influence the per unit cost to distribute a product and alter the wedge between consumer and producer prices (the distribution margin), resulting in dynamics of the firm's elasticity of demand. In contrast to intuitive judgements, the model shows that the short-run difference in demand elasticity between home and foreign products is larger with the second channel. As the retail capacity adjusts in the long run, this difference becomes smaller, and the trade elasticity goes up gradually. Combining these two channels, the model can generate a high (4-5) long-run elasticity of substitution between home and foreign products without conflicting a the low (0.5-1) short-run elasticity. While most trade literature attributes the difference between short-run and long-run trade elasticities to extensive margin movements, my model emphasises the rule of intensive margins.

As an extension of the analysis, I investigate the role of retail capacity in explaining the connection between price volatility and ERPT. Empirical findings by Berger and Vavra (2013) document a positive relationship between price volatility and pass through[4]. I show analytically and quantitatively that this empirical pattern is consistent with differences in retail capacity and distribution margin across firms. In the short run where the retail capacity fails to adjust, ERPT of a firm is positively correlated with the volatility of its import price if (a) the size of idiosyncratic shocks is large and (b) its distribution margin is low. An increase in average distribution margin reduces the correlation between price volatility and ERPT. This correlation also depends on whether the exporter is in control of its local retail network. Simulation results suggest that the change of distribution margin contributes little to the variance of the price for those firms that are not in

[2]Section 2 reviews the related literature.

[3]Drozd and Nosal (2012) provide a possible explanation of the elasticity puzzle based on slow adjustment of consumer list. Due to the adjustment cost on the investment of the market share, the producer cannot raise their market share to the steady state level immediately and the consumer list thus does not update much. This gives a low trade elasticity in the short run because the change of relative price is high and that of relative retail quantity is low. In the long run, the consumer list adjusts and trade elasticity increases. However, in their model, the consumer demand is always equal to the consumer list holding by the producer and the change of prices has no influence on consumer's choice. The equilibrium retail price is determined through the inverse demand function once the demand is chosen. My model differs from theirs in the sense that the consumer demand in my model is jointly determined by the producer's retail price and its retail capacity. The producer can attract more consumers through either a lower price or marketing activities that extend its retail capacity.

[4]New empirical findings on the relationship among firm level characteristics, market structure, price volatility and ERPT are presented in my third chapter.

control of their local retail networks. In contrast, the variance of retail capacity explains 40% of price volatility for those firms directly controlling their retail networks. Furthermore, aggregate shocks are important in explaining the price volatility of retailing manufacturers but not that of non-retailing manufacturers.

The rest of the paper is organised as follows. Section 2 provides a brief literature review on research modelling local component and strategic interactions. Section 3 introduces the basic model. Section 4 extends the basic model and discusses the role of retail capacity in explaining the link among trade elasticity, price volatility and ERPT. Section 5 concludes.

2 Literature Review

Discussion on international relative prices using two-country open-economy DSGE models can be traced back to the early 1990s. At that time, a large number of international macroeconomic models imply the law of one price holds for tradable goods sold across countries and ERPT is perfect [e.g. Backus, Kehoe and Kydland (1992), Obstfeld and Rogoff (1995) and Stockman and Tesar (1995)]. However, the increasing evidence suggesting the failure of the law of one price and the purchasing power parity gives rise to a new group of studies characterising the "pricing to market" behaviour of firms[5]. The term "pricing to market" was first used in Krugman (1986) to indicate that markets are segmented and firms discriminate and charge different markups across countries[6]. In line with Krugman (1986), a large number of literature emphasises the pricing to market behaviour and attributes the incomplete pass through to local nominal rigidities [e.g. Betts and Devereux (2000)]. However, to generate the observed low pass through, they need to set a very high degree of nominal rigidities. Moreover, their models give wrong implications of the relationship between the terms of trade and the exchange rate as critiqued by Obstfeld and Rogoff (2000).

Later studies started to consider reasons apart from the nominal rigidity. These studies can be mainly divided into three groups. The first group emphasises the importance of the local component of consumer price.[7] The existence of the local component drives a wedge between consumer and producer prices, making the elasticity of demand an increasing function of the producer price and resulting in incomplete EPRT at both producer and consumer prices. The second group focuses on variable demand elasticities and markups under different market structures. The dif-

[5]Rogoff (1996) provides a very good literature survey on the failure of the law of one price and the purchasing power parity.

[6]The segmentation of markets may come from various reasons which imply that the cost of arbitrage is not zero. For example, in Goldberg and Verboven (2005)'s survey on the car market, manufacturers prevent local dealers from exporting the car to other countries by threatening to withdraw their franchise.

[7]These studies can also be viewed as literature characterising vertical interactions.

ference in the price elasticity of demand across countries motivates producers to charge different markups. The firm's optimal markup often depends on its horizontal or vertical interaction with other firms. As a result, the import price changes less than one to one with the change in the firm's marginal cost and the nominal exchange rate. The third group studies the exchange rate pass through at the border and has developed models in which exporters can choose whether to price their exports in home currency or in foreign currency, knowing that price updates will be subject to certain frictions[8]. A number of factors such as the local monetary policy stability, the market share of exporters and the exchange rate regime play a crucial role in this choice.

The importance of local components to price discrimination across markets was first pointed out by Corsetti and Dedola (2005). Intuitively, local components produce a wedge between the consumer price and the import price at the border and reduce the sensitivity of consumption to the producer price at the consumer level. The price elasticity of demand with respect to the producer price is a function of distribution margin. As different distribution margins imply distinct demand elasticities across markets, it is optimal for producers to discriminate and charge different prices across countries. An increase in the wholesale price of the firm lowers the distribution margin and increases the demand elasticity. As a result, the desired markup narrows. The optimal wholesale price moves less than one to one in response to a exchange rate shock and ERPT is incomplete. The observation that ERPT at consumer prices is lower compared to ERPT at import prices can be easily explained using this setting. Therefore, models with local components can generate observed low ERPT without assuming huge local nominal rigidities. In addition to incomplete pass through, Corsetti, Dedola and Leduc (2008) based on this setting can generate high volatility of real exchange rates and low volatility of terms of trade relative to real exchange rates, which standard business cycle models fail to capture.

This explanation is highly appreciated by empirical studies. Goldberg and Verboven (2001) conduct a empirical analysis for automobile retail prices in five European countries. They attribute around 38% pass through of the nominal exchange rate to local distribution cost. Hellerstein (2008) builds a structural model to fit panel data in beer industry. He finds the optimal markup adjustment of producer and the existence of local distribution cost equally explain the price stickiness. He argues that foreign exporters bear a greater cost in response to an appreciation of home exchange rate compared to local producers and local retailers.

The intuition of the local component of price can be applied to other contexts. For example, Alessandria (2009) develops a consumer searching model where the searching process is costly but gives the possibility of buying goods at a lower price. The real consumer price can be viewed as producer price with an additive component, i.e. the corresponding searching cost. Following

[8]Since my theoretical models are not directly linked to the optimal currency choice, the detailed literature review of this group is omitted in the literature review section.

the same logic, a higher searching cost leads to a higher markup and ERPT is incomplete due to the additive term to producer prices. Similarly, Drozd and Nosal (2012) assume that producers and local retailers conduct a Nash bargaining with total profit of sales. As a result, exporter's wholesale price P_x denoted in the home currency equals a local component $\eta\varepsilon P_c^*$ plus a portion of the marginal cost where η is the fixed bargaining power for the local retailer.

Research modelling different market structures and ERPT can be categorised into horizontal and vertical interactions. In terms of horizontal interactions, Dornbusch (1987) explains the incomplete ERPT by considering oligopolistic markets in which the optimal adjustment of the markup depends on market structures and the underlying curvature of the demand curve. Atkeson and Burstein (2007) present a simple Ricardian model of international trade where exporters charge a price equal to the marginal cost of their local competitors and thus the ERPT is incomplete. de Blas and Russ (2015) generalise Atkeson and Burstein (2007)'s Bertrand competition setting with multi-countries in which the degree of the price rigidity and the incomplete ERPT depend on the distribution of markups which is in turn determined by the number of competitors.

Among the literature studying horizontal interactions, Atkeson and Burstein (2008) appears to be a very successful explanation. They extend Dornbusch (1987) to capture the fluctuations in the international relative prices. They consider a market with a continuum of sectors and a finite number of differentiated products under each sector. The elasticity of demand across sectors is assumed to be smaller than the elasticity within the same sector. The firm chooses its retail price to maximise its profit subject to the inverse demand function and takes into account that the sector demand will be affected by its price. The demand elasticity is decreasing in the market share. Therefore, a firm with a high market share in its sector assigns a higher weight to the low substitutable competitors across industries and thus has a lower elasticity. Correspondingly, the optimal markup is increasing in the market share. In addition, any price changes of a firm in the industry will change the aggregate industry price and its market share. The elasticity of demand alters accordingly and ERPT is incomplete. They argue that pricing to market behaviour is heterogeneous across firms. The within-sector cost dispersion is central in their paper in the sense that it pins down the distribution of markups and thus the pricing behaviour. In the equilibrium, only large firms choose pricing to market.

Amiti, Itskhoki and Konings (2014) confirm this result using the data of Belgian exporters. They find that exporters with larger market share in the destination market have a lower pass through. Moreover, a higher import intensity of inputs lowers the response to exchange rate shocks. That is, shocks of exchange rates are partially offset by the adverse adjustment of marginal cost due to the change of input prices. They find that the distribution of importers is quite skewed in the sense that large importers are also large exporters. The effect of a depreciation of home currency with respect to all trade partners on export prices is partially offset by the increase in the cost of buying inputs for exporters. They construct a model by combining Atkeson and Burstein (2008) with **?** and attribute half of incomplete ERPT to varying markups with the change of the marginal cost accounting for another half.

Corsetti, Dedola and Leduc (2007) explicitly model strategic vertical interactions among upstream and downstream firms, explore the possible interactions between optimal price setting and nominal rigidities and study their implications on optimal monetary policy. In their model, upstream producers exercise their monopoly power and set different prices for downstream retailers at home and abroad. Local monopolistic downstream firms using one intermediate traded good to produce nontradable final goods then sell the good to the consumer. The nominal rigidity is modelled using Calvo pricing, where only a fraction of upstream producers and downstream retailers can change their price. Therefore, downstream retailers face different marginal costs depending on whether their upstream producer changes price. In addition, upstream producers updating their price will need to consider that only a fraction of downstream firms buying their products will also reoptimise in the same period.

The optimal price depends explicitly on the demand elasticity. The perceived demand elasticity is market-specific, depending on differences in industry-specific inflation rates and the degree of price dispersions in the local market. Therefore the deviation from law of one price comes not only from the nominal rigidity but also from the vertical interaction among upstream and downstream monopolists. Furthermore, the vertical interaction among firms with sticky prices lowers the demand elasticity. Nominal rigidities at the retail level do not necessarily lower the equilibrium reaction of final prices to exchange rate movements due to the strategic substitutability between upstream and downstream firms. They show analytically that upstream nominal rigidities lead to a lower short-run ERPT irrespective of vertical interactions. Nevertheless, downstream nominal rigidities induce a larger price response to exchange rate changes because of strategic substitutability. Under reasonable calibration, the effect of upstream nominal rigidities dominates the effect of downstream ones and the pass through is incomplete.

3 The Basic Model

This section uses a simplified model to introduce my key settings and explain the two channels driving the difference between short run and long run trade elasticities. The world economy consists of two countries, home and foreign, of the same size. The representative household in the home country consumes three types of goods, namely home tradable goods $C(h)$, foreign tradable goods $C(f)$, and nontradable goods $C(n)$. I restrict my analysis to two types of firms, namely retailing manufacturers and non-tradable goods producers. A richer and more realistic model is studied in section 4.

I model the building of retail networks as an investment in the retail capacity k and embed the effect of changing retail networks through the following CES aggregator, i.e.,

$$C_{H,t} \equiv \left[\int_0^1 \left(\frac{k_t(h)}{K_{H,t}} \right)^{\frac{1}{\theta_H \theta_K}} C_t(h)^{\frac{\theta_H - 1}{\theta_H}} dh \right]^{\frac{\theta_H}{\theta_H - 1}}, \quad C_{F,t} \equiv \left[\int_0^1 \left(\frac{k_t(f)}{K_{F,t}} \right)^{\frac{1}{\theta_H \theta_K}} C_t(f)^{\frac{\theta_H - 1}{\theta_H}} df \right]^{\frac{\theta_H}{\theta_H - 1}}$$

$$K_{H,t} \equiv \left[\int_0^1 k_t(h)^{\frac{1}{\theta_K}} dh \right]^{\theta_K}, \quad K_{F,t} \equiv \left[\int_0^1 k_t(f)^{\frac{1}{\theta_K}} df \right]^{\theta_K}$$

where θ_H is elasticity of substitution among home tradable goods and the elasticity of substitution among foreign tradable goods is assumed to be the same as its home counterpart, i.e., $\theta_F = \theta_H$. θ_K reflects the intensity and effectiveness of retail capacity accumulation on consumer's preference. If θ_K is equal to unity, aggregate consumption is just a capacity weighted average of consumption of single products. A higher θ_K indicates that the marginal return of consumption demand in investing retail capacity is low.

The idea of this setting is that a firm should be able to affect consumer's demand through a channel other than price. The investment in the retail network can be viewed as a proxy for all local promotion efforts which increase the demand without affecting the retail price and quality of the product. For example, the producer can advertise their product, which affects the consumer's preference *ex ante*[9]. A higher retail capacity can be interpreted as more retail stores, which makes the product more accessible and reduces the consumer's searching cost. A higher retail capacity may be viewed as a strategy to increase the effectiveness of matching. In the context of Alessandria (2009), it increases the consumer's probability of getting a price quote for the firm. After the purchase of the product, it could be an investment that improves customer services, which affects the demand of the product next period for a reason similar to the deep habit by Ravn, Schmitt-Grohé and Uribe (2006). Mechanically, it provides a simple setting which bypasses the difficulty of using inequality constraints to restrict the demand below the retail capacity.

The aggregation between home and foreign goods can be defined as usual:

$$C_{T,t} \equiv \left[(S_H)^{\frac{1}{\rho}} C_{H,t}^{\frac{\rho-1}{\rho}} + (S_F)^{\frac{1}{\rho}} C_{F,t}^{\frac{\rho-1}{\rho}} \right]^{\frac{\rho}{\rho-1}}$$

where ρ is the elasticity of substitution between home and foreign tradable goods, and the shares

[9] Many empirical marketing studies have made it clear that advertising and marketing can change the consumer's preference on top of the price and quality of the product. See Baker et al. (1986) and **?** for examples.

of the retail network $(S_{H,t}, S_{F,t})$ are given by

$$S_{H,t} = \frac{(K_{H,t})^{\frac{1}{\theta_K}}}{(K_{H,t})^{\frac{1}{\theta_K}} + (K_{F,t})^{\frac{1}{\theta_K}}}, \quad S_{F,t} = \frac{(K_{F,t})^{\frac{1}{\theta_K}}}{(K_{H,t})^{\frac{1}{\theta_K}} + (K_{F,t})^{\frac{1}{\theta_K}}}$$

With the retail network share in the CES aggregator, the change in demand of home tradables, $C_{H,t} = S_{H,t}\left(\frac{P_{H,t}}{P_t}\right)^{-\rho} C_{T,t}$, is driven by two forces. In addition to the conventional mechanism via price, the change in the retail network share plays a nontrivial role. The consumer's demand from the CES aggregation without the retail network share, $\left(\frac{P_t(h)}{P_{H,t}}\right)^{-\theta_H} C_{H,t}$, can be regarded as the potential demand. Without any retail capacity ($S_{H,t} = 0$), the producer cannot sell anything to the consumer. The classical market share measure, which is defined as $\frac{P_H C_H}{P_T C_T}$, can be viewed as a weighted average between the retail network share and the conventional price driven market share.

I take the conventional setting that nontradable goods do not need to go through the distribution process and producers sell directly to buyers.

$$C_{N,t} \equiv \left[\int_0^1 C_t(f)^{\frac{\theta_N - 1}{\theta_N}} dh\right]^{\frac{\theta_N}{\theta_N - 1}}, \quad C_t \equiv \left(C_{T,t}^{\frac{\phi-1}{\phi}} + C_{N,t}^{\frac{\phi-1}{\phi}}\right)^{\frac{\phi}{\phi-1}}$$

The corresponding price aggregators can be derived as

$$P_{H,t} = \left[\int_0^1 \left(\frac{k_t(h)}{K_{H,t}}\right)^{\frac{1}{\theta_K}} p_t(h)^{1-\theta_H} dh\right]^{\frac{1}{1-\theta_H}}, \quad P_{F,t} = \left[\int_0^1 \left(\frac{k_t(f)}{K_{F,t}}\right)^{\frac{1}{\theta_K}} p_t(f)^{1-\theta_H} df\right]^{\frac{1}{1-\theta_H}}$$

$$P_{T,t} = \left[S_{H,t} P_{H,t}^{1-\rho} + S_{F,t} P_{F,t}^{1-\rho}\right]^{\frac{1}{1-\rho}}, \quad P_t = \left[P_{T,t}^{1-\phi} + P_{N,t}^{1-\phi}\right]^{\frac{1}{1-\phi}}$$

3.1 The exporter's problem

The production function of producers is assumed to be linear in labour L and productivity Z, i.e., $Y = ZL$. As this production function has constant returns to scale, the pricing problem of the producer of home tradables for the domestic and foreign markets can be analysed separately.

In the foreign market, the home producer h chooses its price denominated in local currency $P_t^*(h)$ and its investment in the local retail network $i_t^*(h)$ to maximise its expected total profit subject to its marginal cost $MC_{H,t}$, its demand given by the CES aggregator $D_t^*(h)$, and the accumulation process of retail capacity (3).[10]

$$\max_{P_t^*(h), i_t^*(h)} \quad E_t \sum_{\iota=t}^{\infty} Q_{t,t+\iota} \left\{\left[\varepsilon_\iota P_\iota^*(h) - MC_{H,\iota}\right] D_\iota^*(h) - \left[i_\iota^*(h)\right] \varepsilon_\iota P_{N,\iota}^*\right\}$$

[10]The foreign variables are denoted with asterisk and all prices are denominated in the local currency.

subject to

$$D_t^*(h) = \left(\frac{k_t^*(h)}{K_{H,t}^*}\right)^{\frac{1}{\theta_K}} \left(\frac{P_t^*(h)}{P_{H,t}^*}\right)^{-\theta_H} C_{H,t}^* \quad (1)$$

$$MC_{H,t} = \frac{W_t}{Z_{H,t}} \quad (2)$$

$$k_{t+1}^*(h) = i_t^*(h) + (1-\delta)k_t^*(h) - \chi(k_t^*(h)) D_t^*(h) \quad (3)$$

The component $\chi(k_t^*(h)) D_t^*(h)$ in equation (3) is the second key feature of my model. The idea is to model the effectiveness of distribution as a function of existing retail capacity. For each product being sold, $\chi(k_t^*(h))$ units of nontradable goods are required to distribute the product to the consumer. The function $\chi(k) : [0, \infty) \to [0, \infty)$ measures the efficiency of distribution and is assumed to be decreasing in the retail capacity at a decreasing rate.[11] This setting penalises a firm that attempts to temporarily sell at a quantity above its retail capacity. Instead of shutting down the price channel in the short run and letting the demand be completely determined by the retail capacity as in Drozd and Nosal (2012), my setting enables a short-run boost in sales by cutting prices and leaves the firm to trade off between the high cost on distribution and the short-run boost in sales.

Substituting the investment constraint into the objective function, the optimisation problem can be rewritten as:

$$\max_{P_t^*(h), k_{t+1}^*} \quad E_t \sum_{\iota=t}^{\infty} Q_{t,t+\iota} \left\{ \begin{array}{c} \left[\varepsilon_\iota P_\iota^*(h) - MC_{H,\iota} - \chi(k_\iota^*(h)) \varepsilon_\iota P_{N,\iota}^*\right] \left(\frac{k_\iota^*(h)}{K_{H,\iota}^*}\right)^{\frac{1}{\theta_K}} \left(\frac{P_\iota^*(h)}{P_{H,\iota}^*}\right)^{-\theta_H} C_{H,\iota}^* \\ - \left[k_{\iota+1}^*(h) - (1-\delta)k_\iota^*(h)\right] \varepsilon_\iota P_{N,\iota}^* \end{array} \right\}$$

The wholesale price $\overline{P}_{H,t}^*$ is defined as the consumer price $P_{H,t}^*$ net of the per unit distribution cost $\chi(k_{H,t}^*)P_{N,t}^*$:

$$\overline{P}_t^*(h) = P_t^*(h) - \chi(k_t^*(h))P_{N,t}^*$$

As in Corsetti and Dedola (2005), the demand elasticity with respect to the wholesale price $\varepsilon_{D_t^*(h), \overline{P}_t^*(h)}$ is increasing in the wholesale price and decreasing in the distribution margin $\delta_t(h) \equiv \frac{\chi(k_t^*(h))P_{N,t}^*}{P_t^*(h)}$. This satisfies the sufficient condition for incomplete pass through proposed by Marston (1990). As the wholesale price goes up, the optimal markup decreases due to a higher price elasticity of demand.

$$\varepsilon_{D_t^*(h), \overline{P}_t^*(h)} = -\frac{\partial D_t^*(h)}{\partial \overline{P}_t^*(h)} \frac{\overline{P}_t^*(h)}{D_t^*(h)} = \theta_H (1 - \delta_t^*(h))$$

[11] In this analysis, I choose an analytically convenient functional form for $\chi(.)$: $\chi(k) = \frac{\varphi}{k} + \vartheta$, $\chi'(k) = -\frac{\varphi}{k^2}$.

The optimal price is given by

$$P_{H,t}^{*} = \frac{\theta_H}{\theta_H - 1}\left[\frac{MC_{H,t}}{\varepsilon_t} + \chi(k_{H,t}^{*})P_{N,t}^{*}\right]$$

The optimal markup for retail price $P_{H,t}^{*}$ is given by $\frac{\theta_H}{\theta_H-1}\left[1+\frac{\varepsilon_t\chi(k_{H,t}^{*})P_{N,t}^{*}}{MC_{H,t}}\right] = \frac{\overline{P}_t^{*}(h)+\chi(k_t^{*}(h))P_{N,t}^{*}}{MC_{H,t}}$ and is decreasing in retail capacity. The analytical ERPT can be derived as

$$-\frac{\frac{MC_{H,t}}{\varepsilon_t}}{\frac{MC_{H,t}}{\varepsilon_t} + \chi(k_{H,t}^{*})P_{N,t}^{*}} \tag{4}$$

Both wholesale price and retail price move less than one to one to exchange rate shock due to the additive local component[12]. Given the optimal price, the demand elasticity with respect to retail capacity can be derived as follows:

$$\varepsilon_{D_t^{*}(h),k_t^{*}(h)} = \frac{1}{\theta_K} + \theta_H\frac{\chi(k_{H,t}^{*})P_{N,t}^{*}}{\frac{MC_{H,t}}{\varepsilon_t} + \chi(k_{H,t}^{*})P_{N,t}^{*}}$$

The first part represents the marginal benefit from owning a higher retail market share, while the second part represents the gain in demand by having a lower price. Note that the second part is a function of the distribution margin and the elasticity of substitution among home tradable products. If the price competition is intense (θ_H is high), it is optimal for the firm to invest more in retail capacity and lower its prices. Nevertheless, a higher level of retail capacity weakens the benefit of investing per effect of a lower distribution margin. Although it is clear that ERPT is an increasing function of the retail capacity holding, the direction of retail capacity adjustment depends on the types of shocks and choices of other firms.

Compared to Corsetti and Dedola (2005), the size of this component is governed by the firm's choices. The optimal investment is governed by the following expression:

$$\varepsilon_t P_{N,t}^{*} = E_t Q_{t,t+1}\left\{\left[\begin{array}{c}\frac{\frac{1}{\theta_H-1}\left[MC_{H,t}+\varepsilon_t\chi(k_{H,t}^{*})P_{N,t}^{*}\right]}{\theta_K k_{t+1}^{*}(h)} \\ -\chi'\left(k_{t+1}^{*}(h)\right)\varepsilon_{t+1}P_{N,t+1}^{*}\end{array}\right]D_{t+1}^{*}(h) + (1-\delta)\varepsilon_{t+1}P_{N,t+1}^{*}\right\} \tag{5}$$

This equation states that the producer chooses to invest in the distribution capacity until the marginal cost of retail capacity (the left hand side) equals the expected marginal benefit in the future. For the right hand side, $\frac{\frac{1}{\theta_H-1}\left[MC_{H,t}+\varepsilon_t\chi(k_{H,t}^{*})P_{N,t}^{*}\right]}{\theta_K k_{t+1}^{*}(h)}$ reflects the per unit marginal gains from an increase in demand due to a higher market share and $-\chi'\left(k_{t+1}^{*}(h)\right)\varepsilon_{t+1}P_{N,t+1}^{*}D_{t+1}^{*}(h)$

[12]Note that the elasticity of price with respect to marginal cost is the same expression but with different signs. A home appreciation lowers ε_t and increases the price of home product denominated in foreign currency and an increase in marginal cost has the same effect if the retail capacity $k_{H,t}^{*}$ remains constant.

represents the marginal benefit per unit from being more efficient in distribution. Under reasonable assumptions on the distribution efficiency function $\chi(k)$, it can be shown that these two terms, which are multiplied by the demand $D^*_{t+1}(h)$, are both decreasing in the retail capacity. $(1-\delta)\varepsilon_{t+1}P^*_{N,t+1}$ is simply the value of the invested retail capacity next period after the depreciation. For each individual firm, the price of nontradable goods is exogenous. An increase in k^*_{t+1} reduces the first two expressions in the brackets but increases the demand via a lower price and a higher retail market share. There is a trade off between the decrease in the per unit benefits and the increase in the units sold.

3.2 The consumer's problem

The home representative household chooses the optimal consumption C, labour supply L, money holding M, international bonds holding B_H, B_F to maximise his lifetime expected utility[13]:

$$U_t = E_t \sum_{\iota=t}^{\infty} \beta^{\iota-t} \left[\frac{C_\iota^{1-\sigma}}{1-\sigma} + \xi \frac{\left(\frac{M_{\iota+1}}{P_\iota}\right)^{1-\sigma}}{1-\sigma} + \alpha \frac{(1-L_\iota)^{1-\nu}}{1-\nu} \right]$$

subject to

$$M_{t+1} + B_{H,t+1} + \varepsilon_t B_{F,t+1} \leq M_t + (1+i_t) B_{H,t} + (1+i_t^*) \varepsilon_t B_{F,t} + W_t L_t - T_t - P_t C_t + \int_0^1 \pi_t(h)\, dh + \int_0^1 \pi_t(n)$$

where σ measures the degree of risk aversion on consumption; ν measures the disutility of labour; β is the discount factor and the risk aversion parameter on the real money holding is set equal to σ. Two international bonds $B_{H,t+1}$ and $B_{F,t+1}$ are denominated in home and foreign currency respectively. The representative household owns all home firms and receives the profit from all home producers $\int_0^1 \pi_t(h)\, dh + \int_0^1 \pi_t(n)\, dn$.

The government spending is assumed to be 0 such that

$$M_t - M_{t-1} + T_t = 0$$

All seigniorage revenues are rebated to households through lump-sum taxes. Throughout the analysis, I assume that monetary authorities adopt a strict inflation targeting such that nominal price changes are equivalent to CPI based real price changes.

[13] As the utility function is separable in real money balances and consumption, money demand is determined residually. Therefore, the parameter in front of the real money balances does not affect the result of my analysis, thus ξ is arbitrarily set equal to 1.

3.3 Calibration

The rest settings of the basic model and their associated equilibrium conditions are presented in appendices C and D.[14] The model is simulated under symmetric conditions where the value of foreign parameters is assumed to be the same as their home counterparts. A summary of calibration is available in table 3. The calibration of most parameters $(\theta_H, \theta_N, \sigma, \beta, \delta, \nu)$ follows directly from Corsetti, Dedola and Leduc (2008). The retail share aggregation factor θ_K is the key parameter which controls the size of the market share channel. I set θ_K equal to 1.4 such that, with a trade elasticity ρ equal to 2, the benchmark model specified in section 4 produces a short-run elasticity (0.5-1) consistent with the business cycle literature and a long-run elasticity (4-5) consistent with the empirical estimations of Simonovska and Waugh (2014). The elasticity of substitution between tradable and nontradables is set to be 0.74 based on the estimation of Mendoza (1991). The value of the friction parameter γ on the capacity adjustment does not change the direction of impulse responses but slows down the capacity adjustment. I choose γ such that the average adjustment cost is around 0.5% of the current retail capacity.

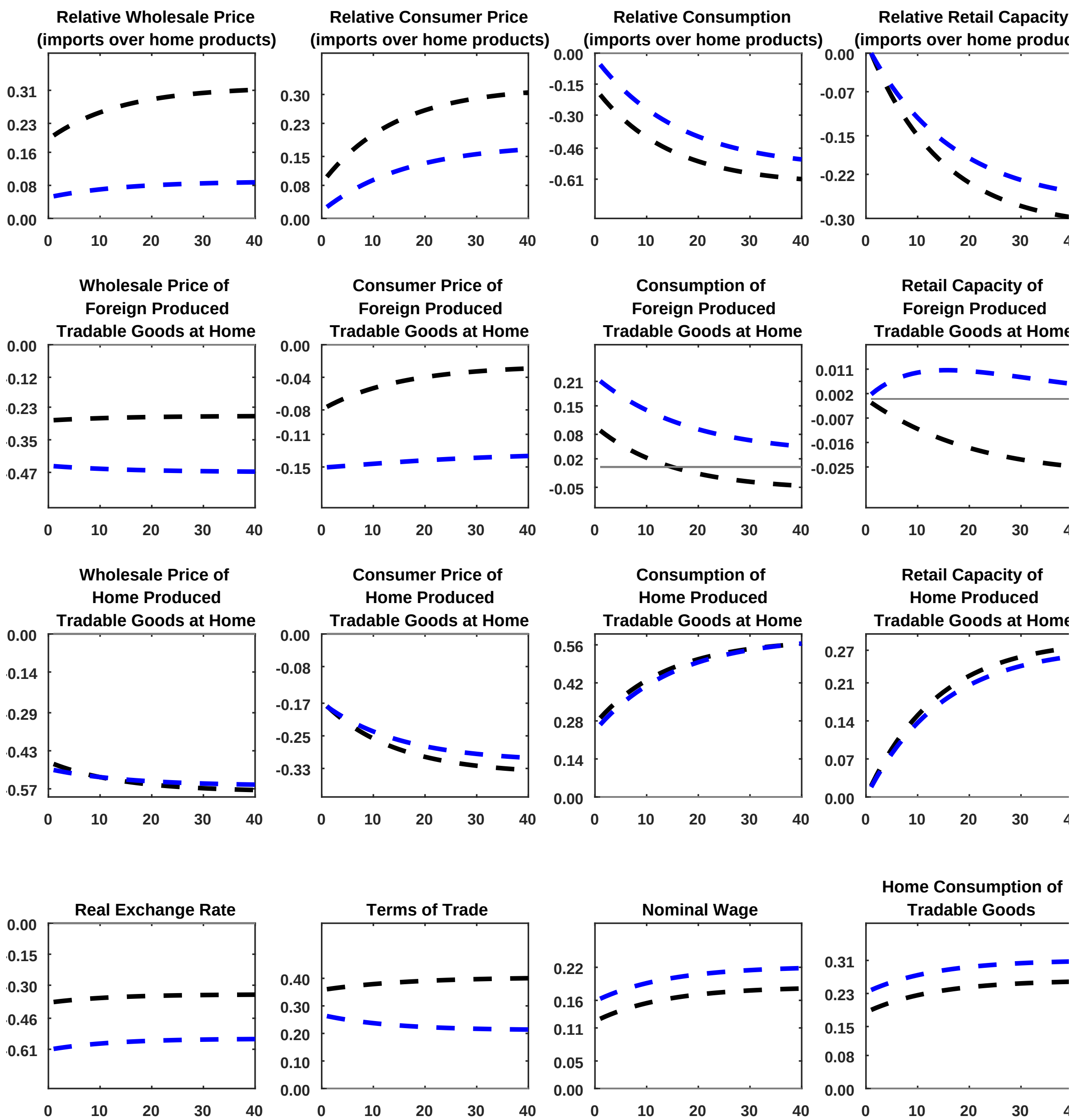
3.4 IRFs and trade elasticity

Figure 1 presents impulse responses to a one percent positive permanent productivity shock on home tradable goods. Upon the shock, the marginal cost of home tradable goods decreases. The price of home tradable goods lowers less than one percent due to the existence of the distribution cost. As the productivity shock is permanent, expected lower price means a higher expected future consumer demand. This leads to additional marginal benefits from investing in the retail capacity. Producers of home tradable goods act according to equation (5) and increase their retail capacity gradually. The price of home tradable goods at the foreign market follows a similar pattern, but at a lower magnitude due to the appreciation of the exchange rate[15]. The change in monetary stance is reflected by the price of nontradable goods, since no distribution service is required for nontradable goods and the producers charge a constant markup over its marginal cost. As there is no shock to the productivity of nontradable goods, the rises in their prices in both countries simply reflect the increase of nominal wages. Intuitively, monetary policy in the home country inflates the nominal wage to counteract the deflation of home tradable prices and the appreciation of nominal exchange rates. The foreign monetary stance extends slightly to offset the deflation caused by the decreased price of imports. Foreign exporters lower their retail price due to the appreciation. ERPT is incomplete as a 0.5% appreciation leads to a 0.15% decrease in price. Since the price decrease is triggered by the exchange rate change rather than the change in marginal cost, the

[14]The basic model is a special case of the generalised model where the proportion of retailing manufacturers is 1.

[15]Due to the strict inflation targeting, the change of the real exchange rate is the same as that of the nominal exchange rate.

Figure 1: In response to a 1 percent positive permanent productivity shock on home tradable goods



Note: The model with and without using the retail network CES aggregator are denoted with blue and black lines respectively. Impulse responses are measured in percentage deviations from the steady state. The horizontal axis denotes quarters after the shock.

effect of the increasing demand is dominated by the rise in the local distribution cost. Therefore, a small decrease in home retail capacity for foreign exporters is observed. As to the foreign tradable goods selling in the foreign market, only a very small increase in its price is observed due to a slight rise of its marginal cost[16]. Nevertheless, a lower demand reduces the incentive of holding retail capacity and K_F decreases over time.

To understand how trade elasticity evolves after a shock, it is helpful to decompose the wholesale price elasticity of substitution between home and foreign goods into three parts:

$$
\begin{aligned}
-\frac{\partial\log\left(\frac{C_F}{C_H}\right)}{\partial\log\left(\frac{\overline{P}_F}{\overline{P}_H}\right)} &= -\frac{\partial\log\left(\frac{S_{F,t}\left(\frac{P_{F,t}}{P_{T,t}}\right)^{-\rho}C_{T,t}}{S_{H,t}\left(\frac{P_{H,t}}{P_{T,t}}\right)^{-\rho}C_{T,t}}\right)}{\partial\log\left(\frac{\overline{P}_F}{\overline{P}_H}\right)} = -\frac{1}{\theta_K}\frac{\partial\log\left(\frac{K_{F,t}}{K_{H,t}}\right)}{\partial\log\left(\frac{\overline{P}_F}{\overline{P}_H}\right)} + \rho\frac{\partial\log\left(\frac{P_{F,t}}{P_{H,t}}\right)}{\partial\log\left(\frac{\overline{P}_F}{\overline{P}_H}\right)} \\
&= -\frac{1}{\theta_K}\frac{\partial\log\left(\frac{K_{F,t}}{K_{H,t}}\right)}{\partial\log\left(\frac{\overline{P}_F}{\overline{P}_H}\right)} + \rho\frac{\partial\log\left[\frac{\left(\chi(k_{F,t})\frac{P_{N,t}}{\overline{P}_{F,t}}+1\right)\overline{P}_{F,t}}{\left(\chi(k_{H,t})\frac{P_{N,t}}{\overline{P}_{H,t}}+1\right)\overline{P}_{H,t}}\right]}{\partial\log\left(\frac{\overline{P}_F}{\overline{P}_H}\right)} \\
&= -\frac{1}{\theta_K}\frac{\partial\log\left(\frac{K_{F,t}}{K_{H,t}}\right)}{\partial\log\left(\frac{\overline{P}_F}{\overline{P}_H}\right)} + \rho\frac{\partial\log\left(\frac{\chi(k_{F,t})\frac{P_{N,t}}{\overline{P}_{F,t}}+1}{\chi(k_{H,t})\frac{P_{N,t}}{\overline{P}_{H,t}}+1}\right)}{\partial\log\left(\frac{\overline{P}_F}{\overline{P}_H}\right)} + \rho
\end{aligned}
\tag{6}
$$

In addition to the conventional price effect of demand ρ, the change in relative demand is affected by two additional channels reflecting the effect of changing retail capacity. The first term in equation (6) captures the "retail market share channel" of demand where the change in the relative price affects the optimal retail capacity and alters relative retail network shares. The second term reflects the "distribution margin channel" where the wholesale price does not move one to one with the retail price due to the existence of the distribution margin. It is easy to verify that this part is negative with a given price of nontradables and constant retail capacity.

Similarly, the elasticity of substitution measured at the consumer price can be derived as follows.

$$
-\frac{\partial\log\left(\frac{C_F}{C_H}\right)}{\partial\log\left(\frac{P_F}{P_H}\right)} = -\frac{1}{\theta_K}\frac{\partial\log\left(\frac{K_F}{K_H}\right)}{\partial\log\left(\frac{P_F}{P_H}\right)} + \rho \tag{7}
$$

I now compare the model using the conventional CES aggregator, denoted as CES (black), with the model using the retail network CES aggregator, denoted as RNCES (blue). For the CES model, the trade elasticity with respect to the producer (wholesale) price is low in the short run and

[16]Due to the strict inflation targeting, the foreign monetary stance extends slightly to offset the deflation introduced by a decreased price of imports.

gradually back to the calibrated value in the long-run. The relative distribution margin decreases immediately after the shock but gradually returns to zero in the steady state. However, the trade elasticity with respect to consumer prices stays constant since this elasticity is not affected by the distribution margin channel.

The RNCES model amplifies the difference between shot-run and long-run trade elasticities. It is important to note that this amplification effect does not necessarily work through enlarging the magnitude of responses. It is the relative magnitude of relative changes that matters. The lower panel of graphs in figure 1 shows that the magnitude of responses measured by their percentage deviation from the steady state is actually smaller for the RNCES model. For the CES model, the relative consumer price of imports over home products increases gradually by a large amount. However, the increase in the relative consumption is even bigger. The increase in the relative consumption is twice as much as the increase in the relative consumer price, resulting in a constant trade elasticity at consumer prices of 2. For the RNCES model, the change in the relative price is much smaller than that for the CES model but the difference in changes in the relative consumption between RNCES and CES models is relatively small, resulting in a steady increase in the trade elasticity at the consumer and producer prices over time.

4 The Full Model

This section considers a more realistic market structure and allows for four types of firms interacting with each other, namely retailing manufacturers, non-retailing manufacturers, local retailers and nontradable goods producers. For each type of tradable goods, there is a proportion of non-retailing manufacturers who sell to local retailers and do not manage their own retail network. Local retailers sell a range of home and foreign tradables goods, set the retail price for each product and adjust their retail networks according to all products they sell.

The optimisation problem of foreign local retailer r is as follows. The foreign local retailer r buys a range of imports and home products and sets the retail price $P_t^*(h_r, r)$, $P_t^*(f_r, r)$ to maximise its profits subject to the demand of product $D_t^*(h_r, r)$, $D_t^*(f_r, r)$ and chooses this optimal investment $i_t^*(r)$ for all products it sells subject to the law of motion of retail capacity. For each individual product h_r, f_r the marginal cost is $P_{im,t}^*(h_r, r)$, $P_{local,t}^*(f_r, r)$. The total profit is constructed by aggregating profits and subtracting the total cost of investments made $i_t^*(r) P_{N,t}^*$ to extend retail capacity.

$$\max_{\{P_\iota^*(h_r,r), P_\iota^*(f_r,r), i_\iota^*(r)\}_{\iota=t}^{\infty}} E_t \sum_{\iota=t}^{\infty} Q_{t,t+\iota} \left\{ \begin{array}{c} \int_x^1 \left[P_\iota^*(h_r, r) - P_{im,\iota}^*(h_r, r)\right] D_\iota^*(h_r, r) dh_r + \\ \int_x^1 \left[P_\iota^*(f_r, r) - P_{local,\iota}^*(f_r, r)\right] D_\iota^*(f_r, r) df_r - i_\iota^*(r) P_{N,\iota}^* \end{array} \right\}$$

subject to

$$D_t^*(h_r, r) = \left(\frac{k_t^*(r)}{K_{H,t}^*}\right)^{\frac{1}{\theta_K}} \left(\frac{P_t^*(h_r, r)}{P_{H,t}^*}\right)^{-\theta_H} C_{H,t}^*$$

$$D_t^*(f_r, r) = \left(\frac{k_t^*(r)}{K_{F,t}^*}\right)^{\frac{1}{\theta_K}} \left(\frac{P_t^*(f_r, r)}{P_{F,t}^*}\right)^{-\theta_H} C_{F,t}^*$$

$$k_{t+1}^*(r) = i_t^*(r) + (1-\delta)k_t^*(r) - \chi_2(k_t^*(r)) \int_x^1 D_t^*(h_r, r)dh_r - \chi(k_t^*(r)) \int_x^1 D_t^*(f_r, r)df_r$$

The law of motion of retail capacity is similar to (3) where $\chi_2(k_t^*(r)) \int_x^1 D_t^*(h_r, r)dh_r$ and $\chi(k_t^*(r)) \int_x^1 D_t^*(f_r, r)df_r$ are the distribution costs for the sales of all imports and local products respectively.[17] In this case, home product h_r competes with other home products based on retail networks of its embedded local retailers and has a retail market share of $\frac{k_t^*(r)}{K_{H,t}^*}$. The cost of selling to local retailers is the drop in sales because the product is sold at a higher price due to the additional markup charged by local retailers.

The optimal retail prices are given by

$$P_t^*(h_r, r) = \frac{\theta_H}{\theta_H - 1}\left[P_{im,t}^*(h_r, r) + \chi_2(k_t^*(r))P_{N,t}^*\right]$$

$$P_t^*(f_r, r) = \frac{\theta_H}{\theta_H - 1}\left[P_{local,t}^*(f_r, r) + \chi(k_t^*(r))P_{N,t}^*\right]$$

The optimal price reflects two components that affect ERPT, namely the double marginalisation and the distribution margin.

The optimal retail capacity for foreign local retailers hinges on the purchase price and demand of all home and foreign products.

$$P_{N,t}^* = E_t Q_{t,t+1} \left\{ \begin{array}{c} \int_x^1 \left[\frac{P_t^*(h_r,r) - P_{im,t}^*(h_r,r) - \chi_2(k_t^*(r))P_{N,t}^*}{\theta_K k_{t+1}^*(r)} - \chi_2'\left(k_{t+1}^*(r)\right) P_{N,t+1}^*\right] D_{t+1}^*(h_r)dh_r \\ + \int_x^1 \left[\frac{P_t^*(f_r,r) - P_{local,t}^*(f_r,r) - \chi(k_t^*(r))P_{N,t}^*}{\theta_K k_{t+1}^*(r)} - \chi'\left(k_{t+1}^*(r)\right) P_{N,t+1}^*\right] D_{t+1}^*(f_r)df_r \\ +(1-\delta)P_{N,t+1}^* \end{array} \right\}$$

For a home exporter h_r its demand is the sum of demand of all foreign local retailers:

$$D_t^*(h_r) = \int_0^1 D_t^*(h_r, r)dr = \int_0^1 \left(\frac{k_t^*(r)}{K_{H,t}^*}\right)^{\frac{1}{\theta_K}} \left(\frac{P_t^*(h_r, r)}{P_{H,t}^*}\right)^{-\theta_H} C_{H,t}^* dr$$

Substituting $P_t^*(h_r, r)$ with the price set by local retailers and using the assumption that local

[17] I allow for different distribution cost functions to promote local and foreign products, $\chi(.)$ and $\chi_2(.)$.

retailers are homogeneous, the demand can be written as

$$D_t^*(h_r) = \left(\frac{K_{R,t}^*}{K_{H,t}^*}\right)^{\frac{1}{\theta_K}} \left(\frac{\frac{\theta_H}{\theta_H-1}\left[P_{im,t}^*(h_r) + \chi_2(K_{R,t}^*)P_{N,t}^*\right]}{P_{H,t}^*}\right)^{-\theta_H} C_{H,t}^*$$

Given the demand from local retailers, the non-retailing exporter's problem is therefore

$$\max_{P_{im,t}^*(h_r)} \quad \left[\varepsilon_t P_{im,t}^*(h_r) - MC_t(h_r)\right] \left(\frac{K_{R,t}^*}{K_{H,t}^*}\right)^{\frac{1}{\theta_K}} \left(\frac{\frac{\theta_H}{\theta_H-1}\left[P_{im,t}^*(h_r) + \chi_2(K_{R,t}^*)P_{N,t}^*\right]}{P_{H,t}^*}\right)^{-\theta_H} C_{H,t}^*$$

Its optimal price is given by

$$P_{im,t}^*(h_r) = \frac{\theta_H}{\theta_H - 1}\left[\frac{1}{\theta_H}\chi_2(K_{R,t}^*)P_{N,t}^* + \frac{MC_t(h_r)}{\varepsilon_t}\right]$$

Similarly, the optimal price for local products can be derived as

$$P_{local,t}^*(f_r) = \frac{\theta_H}{\theta_H - 1}\left[\frac{1}{\theta_H}\chi(K_{R,t}^*)P_{N,t}^* + MC_t(f_r)\right]$$

The retailer's price expressed in terms of producer's marginal cost and distribution margin is:

$$P_t^*(h_r, r) = \left(\frac{\theta_H}{\theta_H - 1}\right)^2 \left[\chi_2(k_t^*(r))P_{N,t}^* + \frac{MC_t(h_r)}{\varepsilon_t}\right]$$

where $\left(\frac{\theta_H}{\theta_H-1}\right)^2$ reflects double marginalisation. The ERPT at retail prices is given by

$$\frac{\frac{MC_t(h_r)}{\varepsilon_t}}{\chi_2(k_t^*(r))P_{N,t}^* + \frac{MC_t(h_r)}{\varepsilon_t}}$$

The analytical ERPT of the retail price is similar to the expression of equation (4) implying that double marginalisation does not affect ERPT at the consumer price. ERPT will be the same if retailing and non-retailing manufacturers have the same retail capacity. However, simulation shows that local retailers accumulate the largest amount of retail capacity, followed by home retailing manufacturers and foreign exporters. By selling to the local retailer, non-retailing exporters are able to utilise the large retail network accumulated by local retailers and lower their distribution margin, resulting in a high ERPT.

The home bias in tradables arises naturally under two circumstances: (1) There exists an iceberg trade cost or trade barriers which increase the optimal prices charged by exporters. The increase in price lowers the demand and thus lowers the gain from investing in the retail capacity. As a result, the foreign retailing exporters optimally reduce their retail capacity, which lowers the market share of foreign goods and leads to home bias. (2) *Ceteris paribus*, it is more costly to promote and sell the foreign good, i.e., distribution cost function for foreign products $\chi_2(k)$ first order stochastically dominates that for home products $\chi(k)$. The higher cost for each unit of product sold leads to a lower level of the retail capacity for foreign retailing exporters. In this case, the lower market share reflects the difficulty to promote and distribute imported goods in the local market if domestic tradables and foreign tradable goods have the same quality. With an iceberg trade cost of 3% and 10% additional cost of distributing foreign products, the benchmark model gives an import share of 8%.

The rest of the model and their associated equilibrium conditions are presented in section C in appendix. All equilibrium conditions for the extended model are summarized in section D in appendix.

4.1 Calibration and key statistics

On top of the calibration of the basic model, seven additional parameters need to be calibrated, namely τ, φ_H, φ_F, ϑ, ζ_1, ζ_2 and the proportion of retailing manufacturers Ξ. Following Ghironi and Melits (2005), the iceberg trade cost τ is set to 3%. The fixed part of the distribution cost function ϑ is calibrated such that the distribution margin is in the range of 40% to 60%. With 10% additional distribution cost for distributing foreign products ($\varphi_F = 1.1\varphi_H$), the model could generate a high degree of home bias and give an import share of around 8%. The proportion of retailing manufacturers Ξ is a parameter which may differ across markets. I have not found enough empirical evidence to calibrate it. In the benchmark model, I select the Ξ which matches the best with the calculated moments from data.[18] ζ_1 and ζ_2 are related to endogenous discount factors.[19] ζ_1 controls the variance of the discount factor and ζ_2 is chosen such that the steady state real interest rate is around 1 percent per quarter. Technology shocks are assumed to follow a trend-stationary AR(1) process, $\boldsymbol{Z}_t' = \psi \boldsymbol{Z}_{t-1}' + \boldsymbol{u}_t$,where $\boldsymbol{Z}_t = [Z_{T,t}, Z_{N,t}]$ is a vector of the productivity of tradable and nontradable goods respectively. I use the same auto-correlation and variance-covariance matrices as in Corsetti, Dedola and Leduc (2008).

Table 6 in the appendix estimates ERPT for all types of firms using data generated by the model. Together with the average distribution margin reported in the key statistics table, it can be seen that a higher distribution margin reduces the pass through. This result is consistent with the analytical expression where the level of pass through is negatively correlated with the distribution margin. Furthermore, the difference between the short-run and the long-run ERPT increases in

[18] The basic model analyses the response of the economy assuming $\Xi = 1$.

[19] Following Schmitt-Grohé and Uribe (2003) and Corsetti, Dedola and Leduc (2008), the extended model introduces the endogenous discount factor for the representative household taking the following form:
$\beta_t = \ln\left\{\zeta_1\left[1+\zeta_2\left(C_t + \frac{M_{t+1}}{P_t} + \alpha\left(1-L_t\right)\right)\right]\right\}$

the level of the distribution margin.

The model's ability to match data patterns of international business cycles and international relative prices is summarised by tables 4 and 5 in the appendix. Empirical moments are calculated based on quarterly data from 1980:1 - 2013:2. The model performs better in terms of the correlation of international prices. In addition, the benchmark model can successfully generate a smaller international consumption correlation compared to the output correlation. With reasonably small frictions on distributing foreign products and a standard iceberg trade cost, the model can generate a sizeable home bias per effect of the retail resource competition. Introducing frictions on capacity adjustment to the benchmark model lowers the variance of investment and further improves the fitness.

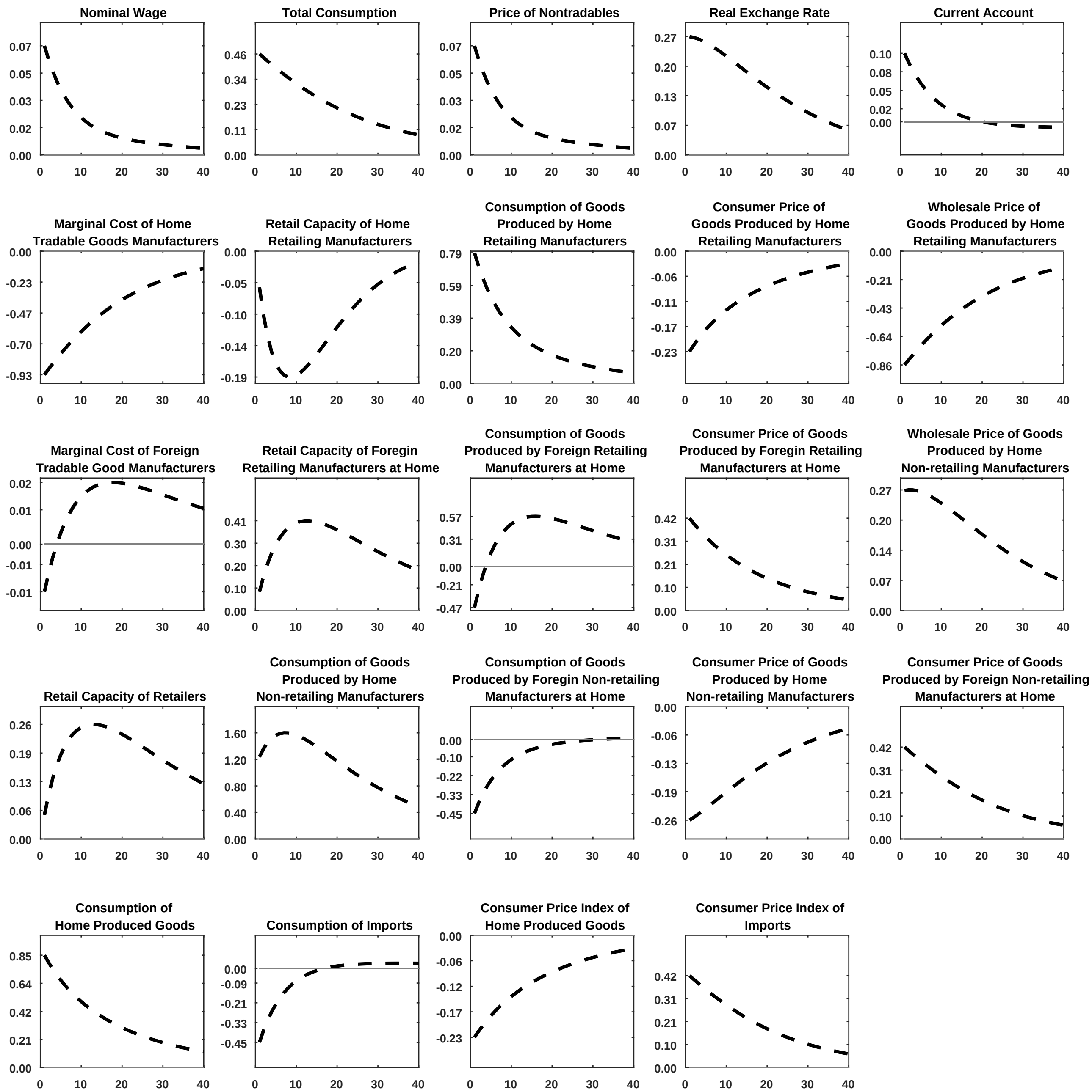
4.2 The analysis of impulse responses

4.2.1 The response to a positive productivity shock on tradable goods

Figure 2 presents impulse responses to a persistent positive productivity shock in the benchmark model with frictions on capacity adjustment. The productivity shock is assumed to follow an AR(1) process with a persistent parameter equal to 0.95. Upon the shock, home producers of tradable goods face a lower marginal cost and choose to lower their prices. At the equilibrium, more products are produced and the demand for labour increases, which in turn increases the equilibrium wage. As a result, the representative household consumes less leisure, supplies more labour and earns more. Due to the wealth effect, the representative household consumes more domestic products as well as imports. The real exchange rate depreciates and home products are sold more in both domestic market and foreign markets. As tradable goods and nontradable goods are complements, more nontradable goods are needed as sales of tradable goods rise. The price of nontradable goods goes up. The expected increase in sales for home products drops over time as the technology shock dies out. Similarly, the price of nontradable good falls gradually after a large impulse increase. Knowing that the price of nontradables is high today but low tomorrow, home retailing manufacturers choose to disinvest today and increase their investment when the price of investment is at a relatively low level. This gives an example where a lower price and a higher expected demand are not accompanied by an increase in the retail capacity due to horizontal competitions of retail resources with local retailers.

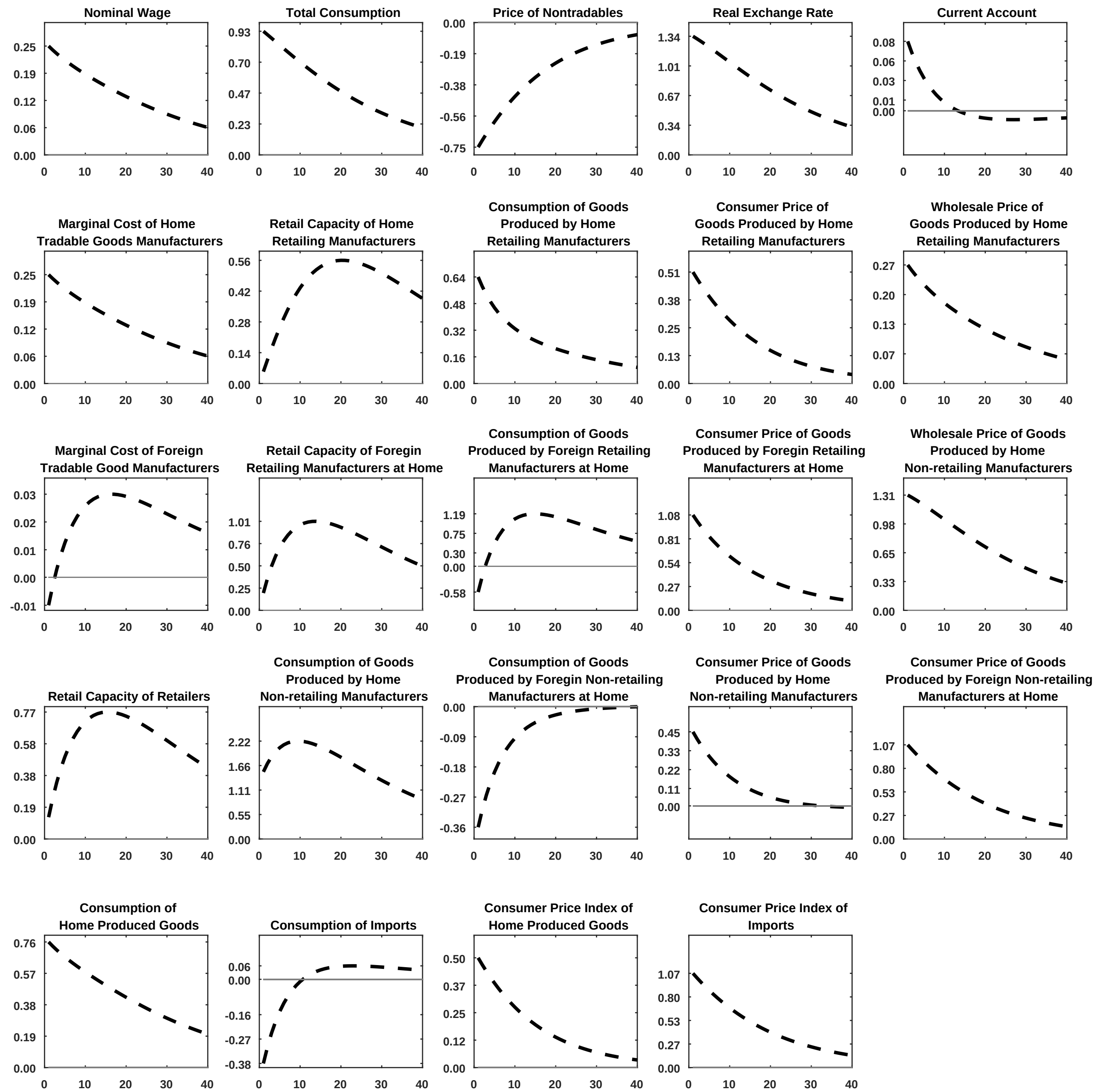
Due to the spillover effect, foreign exporters face an increase in marginal cost. Upon the shock, foreign retailing manufacturers increase their price and face a drop in demand of around 5%. As a result, the consumption of home products increases while the consumption of foreign products goes down. The relative consumption drops. The foreign exporters will have a large drop in quantities sold in home markets if they do not adjust their distribution capacity. Although the

Figure 2: In response to a positive persistent productivity shock on home tradables



Note: The black dashed line denotes the impulse response of the benchmark model with frictions on capacity adjustment. Impulse responses are expressed in percentage deviations from the steady state. The horizontal axis denotes quarters after the shock. Please check table 9 for references of variable names.

Figure 3: In response to a positive persistent productivity shock on home nontradable goods



Note: The black dashed line denotes the impulse response of the benchmark model with frictions on capacity adjustment. Impulse responses are expressed in percentage deviations from the steady state. The horizontal axis denotes quarters after the shock. Please check table 9 for references of variable names.

price of investment is relative high now, the benefit of the gain in demand outweighs the cost of investment, and foreign retailing manufacturers invest gradually to increase their retail market share. In this case, the relative retail capacity goes up gradually. The positive effect of a higher retail market share on demand dominates the negative effect of a high price. The demand for foreign products increases.

As specified in the previous section, the investment decision of local retailers depends on the quantity and price of both home and foreign products. Non-retailing manufacturers do not have controls over their retail networks and their prices decrease proportionally to the marginal cost shock. Similarly, import prices of foreign non-retailing manufacturers increase slightly per effect of the exchange rate depreciation and the small increase in their marginal cost. The relative price of retailing manufacturers decreases. Retailers face an increase in demand for home produced products and a decrease in demand for imported goods. At equilibrium, they end up choosing to extend their retail networks to amplify the gain from home products and partially make up their loses from imports.

4.2.2 Shock on nontradable goods

A positive and persistent shock on nontradable goods reduces the marginal cost of producers of nontradable products. The price of nontradables thus decreases and sales of nontradables increase. The demand of labour increases, giving rise to a higher wage. At the equilibrium, the representative household supplies more labor and consumes more, increasing the demand of all products.

Local retailers, home and foreign retailing manufacturers choose to expand their retail capacity subject to two effects, namely the demand effect and price effect. On the one hand, expected demand increases, which gives rise to larger total benefit of investment in retail capacity and thus induces a higher retail capacity holding. On the other hand, the price of investment is low at the moment and is expected to increase. It is optimal to invest now and disinvest when the cost is high. Due to frictions on adjusting retail capacity, the capacity cannot adjust directly to the desired level. Simulation shows that the price effect outweighs the demand effect with the retail capacity reaching the highest after 15 quarters.

The marginal cost of home tradable goods increases and home retailing manufacturers increase their price. However, the price increase of home retailing manufacturers is less than the drop in their marginal cost as the distribution cost drops. Prices of imports increase more than home prices due to the depreciation of real exchange rates. Note that the pass through for import prices is very high. Given a small increase in the marginal cost, the import price almost increases one-to-one to the real exchange rate. At the consumer level, the price of these products increases less than the price of imported products does. The relative price of local retailer selling products rises. As a consequence, sales of foreign retailing manufacturers drop initially. To prevent a further decline in their demand, it is optimal for them to invest more in the retail capacity compared to home retailing manufacturers. Their sales gradually go up as their retail networks expand. The choice of expanding the retail capacity is also based on fact that the expected demand in the future is relatively high as the exchange rate of home country depreciates. The relative demand is initially lower than the steady state value but gradually goes up as the foreign retail capacity expands until the depreciation stops.

4.3 Trade elasticities

Table 1 presents OLS estimation results of elasticity of substitutions based on simulated series. In the benchmark model without frictions on adjusting investment, any shock that changes the desired retail capacity will be adjusted instantly. In column (1) , regressions controlling for relative retail capacity (part a) reflect the short-run trade elasticity. This elasticity is captured by the coefficient on the change of relative price, e.g. $|-1.9782|$. Regression results of part (b) imply the long-run trade elasticity.

The first set of regressions estimate the trade elasticity between home and foreign tradables goods. These goods include products of both retailing and non-retailing manufacturers. The estimated short run trade elasticity is around the calibrated value of 2. The coefficient on the relative change in retail capacity is positive, consistent with the analytical decomposition in equation (6). The second set of regressions estimate the elasticity of substitution between home and foreign retailing manufacturers. This elasticity in the short-run is slightly lower than the calibrated value and the implied long-run elasticity is as high as 4.22. The last set of regressions measure the elasticity of substitution between retailers selling home products and imports. Estimations of part (c) and (d) in the bottom panel are based on relative retail prices and relative producer prices respectively.

The column (2) presents results of the model with frictions on retail capacity adjustments. The short-run trade elasticity is estimated to be 2.03, similar to the benchmark model. Since the retail capacity cannot be adjusted immediately, estimates of part (b) are similar to those of part (a). Note that adding frictions on retail capacity adjustment changes the dynamics of responses of home and foreign retailing manufacturers. Decisions on prices and optimal capacity are more complicated as these firms react based on their expectations of future nontradable price and their shares of retail networks. The estimated trade elasticity reacts in a smaller magnitude compared to the benchmark model due to a stronger competition effect from local retailers. The associated R-squared is much lower compared to the benchmark model, indicating that there exists non-pricing explanatory factors and that the current regression specification fails to capture the adjustment process of relative consumption.

Table 1: Estimated elasticity of substitution between home and foreign products

Dependent Variable		Explanatory Variables	(1) Benchmark	(2) Benchmark + Capacity Adjustment Friction
$Y: \log \frac{C_{F,t}}{C_{H,t}}$	(a):	$\log \frac{P_{F,t}}{P_{H,t}}$	-1.9782	-2.0367
			(0.0110)	(0.0010)
		$\log \frac{K_{F,t}}{K_{H,t}}$	0.6857	0.7141
			(0.0050)	(0.0006)
		R^2	0.9810	0.9981
	(b):	$\log \frac{P_{F,t}}{P_{H,t}}$	-3.2442	-1.9029
			(0.0076)	(0.0110)
		R^2	0.9476	0.7504
$Y: \log \frac{C_{FD,t}}{C_{HD,t}}$	(a):	$\log \frac{P_{FD,t}}{P_{HD,t}}$	-1.7962	-0.8125
			(0.0161)	(0.0200)
		$\log \frac{K_{FD,t}}{K_{HD,t}}$	0.8549	0.4982
			(0.0044)	(0.0079)
		R^2	0.9539	0.3323
	(b):	$\log \frac{P_{FD,t}}{P_{HD,t}}$	-4.2215	-0.6137
			(0.0226)	(0.0267)
		R^2	0.7777	0.0647
$Y: \log \frac{C_{RF,t}}{C_{RH,t}}$	(c):	$\log \frac{P_{RF,t}}{P_{RH,t}}$	-3.5466	-3.7320
			(0.0462)	(0.0148)
		R^2	0.3710	0.8634
	(d):	$\log \frac{P_{IM,t}}{P_{L,t}}$	-2.1369	-2.2249
			(0.0277)	(0.0146)
		R^2	0.3749	0.8620

Note: Standard errors are reported in parentheses.

In the bottom panel, the estimated coefficients are very similar in two model specifications. This is due to the separation between pricing and retailing decisions. Non-retailing manufacturers only make price decisions at each period, taking the local retailer's decision on the optimal retail capacity as given. In addition, when the local retailer adjusts its retail capacity, home and foreign non-manufacturers are affected equally as they share the same retailing network.

4.4 Price volatility and distribution margin

In this subsection, I discuss the model implications on the connections among distribution margin, price volatility and ERPT. Specifically, I derive the short-run analytical expression of the correlation between price volatility and ERPT in terms of the distribution margin, and explore the long-run relationship using simulated data from the model.

Recall that the optimal price of home retailing manufacturers at the foreign country can be expressed as:

$$P_t^* (h_d) = \frac{\theta_H}{\theta_H - 1} \left[\frac{MC_{H,t}}{\varepsilon_t} - \chi_2(k_t^* (h_d)) P_{N,t}^* \right]$$

This expression can be approximated by

$$p_t^* (h_d) \approx - \frac{\frac{MC_t(h_d)}{\varepsilon_t}}{\frac{MC_t(h_d)}{\varepsilon_t} + \chi_2(k_t^* (h_d)) P_{N,t}^*} (z_t (h_d) + e_t) + \frac{\chi_2(k_t^* (h_d)) P_{N,t}^*}{\frac{MC_t(h_d)}{\varepsilon_t} + \chi_2(k_t^* (h_d)) P_{N,t}^*} (\omega_t (h_d))$$

where $p_t^* (h_d)$ is approximated at the first order around time t, and $p_t^* (h_d), z_t (h_d), e_t, \omega_t (h_d)$ represent the first difference of logged variable $P_t^* (h_d), Z_t (h_d), \varepsilon_t$ and distribution cost $\chi_2 (k_t^* (h_d)) D_t^*(h_d)$.

Define $\eta_t (h_d) \equiv \frac{\chi_2(k_t^*(h_d)) P_{N,t}^*}{\frac{MC_t(h_d)}{\varepsilon_t} + \chi_2(k_t^*(h_d)) P_{N,t}^*}$ which is proportional to the distribution margin at time t and the analytical pass through equals $1 - \eta_t (h_d)$. The short-run variance around t can be written as

$$var (p_t^* (h_d)) = \begin{array}{c} [1 - \eta_t (h_d)]^2 \, var (z_t (h_d) + e_t) + \eta_t (h_d)^2 \, var (\omega_t (h_d)) \\ -2\eta_t (h_d) [1 - \eta_t (h_d)] \, cov (z_t (h_d) + e_t, \omega_t (h_d)) \end{array}$$

Note that both short-run pass though and price volatility are functions of distribution margin. Although the retail capacity fails to adjust in the short run, the price of nontradables may not be constant. With idiosyncratic shocks that do not alter the price of nontradables, the second and third terms on the right hand side are nearly zero and the exchange rate pass through is perfectly correlated with price volatility. In order for short-run pass through to be positively correlated with the short-run price volatility, the following expression must be true:

$$\frac{\partial var\left(p_t^*\left(h_d\right)\right)}{\partial\left[1-\eta_t\left(h_d\right)\right]}=\begin{array}{c}2\left[1-\eta_t\left(h_d\right)\right]var\left(z_t\left(h_d\right)+e_t\right)-2\eta_t\left(h_d\right)var\left(\omega_t\left(h_d\right)\right)\\-2\left[1-2+2\eta_t\left(h_d\right)\right]cov\left(z_t\left(h_d\right)+e_t,\omega_t\left(h_d\right)\right)\end{array}>0$$

Since idiosyncratic shock is unlikely to be correlated with change in aggregate prices and exchange rates, we have

$$\begin{array}{rcl}var\left(z_t\left(h_d\right)\right) & > & \frac{1}{1-\eta_t\left(h_d\right)}\left[var\left(\omega_t\left(h_d\right)\right)+cov\left(z_t\left(h_d\right)+e_t,\omega_t\left(h_d\right)\right)\right]\\ & & -var\left(z_t\left(h_d\right)+e_t+\omega_t\left(h_d\right)\right)\end{array}$$

In the short run where the retail capacity fails to adjust, the exchange rate pass through of a firm is positively correlated with the volatility of its import price if (a) the size of the idiosyncratic shocks is very large and (b) its distribution margin is low. According to (b), an increase in distribution margin reduces the correlation between ERPT and price volatility, i.e.,

$$\frac{\partial^2 var\left(p_t^*\left(h_d\right)\right)}{\partial\left[1-\eta_t\left(h_d\right)\right]\partial\eta_t\left(h_d\right)}=-2\left[var\left(z_t\left(h_d\right)+e_t\right)+var\left(\omega_t\left(h_d\right)\right)+2cov\left(z_t\left(h_d\right)+e_t,\omega_t\left(h_d\right)\right)\right]<0$$

According to Berger and Vavra (2013), firm idiosyncratic shocks account for more than 90% of the total variance of prices, which suggests a high correlation between ERPT and exchange volatility. If the relationship holds in short run, the long-run volatility of price must be decreasing in the distribution margin.

To understand the long-run properties of price volatility, I run several regressions of simulated response of prices to idiosyncratic shocks as well as aggregate shocks. I examine additional idiosyncratic shocks of different sizes to individual firms and calculate firms' responses over 10000 periods based on simulated aggregate variables. Variances are calculated based on logged and first differenced variables. pfr, pim and pfd denote home retail prices of foreign non-retailing manufacturers, home import prices of foreign non-retailing manufacturers and home retail prices of foreign retailing manufacturers respectively. Results are summarised in table 2. The first regression for each price is similar to the one run by Berger and Vavra (2013). In the first set of regressions (labelled with (1)), the corresponding coefficients on the variance of nominal exchange rate are always significant. However, the low R-squared of these regressions suggests that the change in exchange rate only explains a very small part of the variance of the import prices.

The second set of regressions (labelled with (2)) add the variance of marginal cost of the firm and its distribution margin. Coefficients on marginal costs are highly significant for all three prices. The contribution of the variance of distribution margin is low for pfr and pim. Note that these types of firms sell their product through local retailers and cannot adjust their retail capacity under the idiosyncratic shocks. These two regressions illustrate that the change in nontradable prices does not affect the variance of the price significantly for non-retailing manufacturers. On the contrary, the variance of distribution margin explains 40% for retailing manufacturers.

The last set of regressions (labelled with (3)) separate the idiosyncratic shocks from aggregate shocks and separate the change in retail capacity from the change in nontradable prices. Results show that idiosyncratic shocks are important in explaining variance of prices. The effect of aggregate shocks is significant for non-retailing manufacturers but not for retailing manufacturers. In addition, the coefficient of variance of aggregate productivity shock on retail prices of non-retailing manufacturers is lower compared to the second set of regressions, suggesting that local retailers partially adjust their retail networks.

Table 2: Decomposition of price volatility

	$var(pfr(i)_t)$			$var(pim(i)_t)$			$var(pfd(i)_t)$		
Coefficients	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
$var(\varepsilon_t)$	0.9351	0.9149	0.4306	2.0248	1.8851	1.3645	0.4050	0.8677	0.0787
	(0.1968)	(0.0490)	(0.0075)	(0.5625)	(0.1396)	(0.0140)	(0.2137)	(0.0466)	(0.0269)
$var(mcf(i)_t)$		0.3134			0.9130			0.2505	
		(0.0031)			(0.0057)			(0.0099)	
$var(dc(i)_t)$		0.0002			0.0022			2.8549	
		(0.0030)			(0.0057)			(0.2819)	
$var(e_t)$[a]			0.6548			1.8490			0.0650
			(0.0059)			(0.0169)			(0.0874)
$var(MCF_t)$			0.0503			1.1590			-0.0462
			(0.0318)			(0.0908)			(0.0301)
$var(K_{R,t}\ or\ k_{fd,t})$			-0.3474			-3.2638			1.7211
			(0.7743)			(2.2071)			(0.2296)
$var(P_{N,t})$			-1.8472			-4.9040			-1.8883
			(0.4215)			(1.2015)			(0.3993)
R^2	0.0434	0.9630	0.9565	0.0254	0.9625	0.9810	0.0072	0.9710	0.9548
Shock Decomposition for Regression (2) $var(Prices)$		3.12e-04			9.41e-04			3.10e-04	
$var(\varepsilon_t)$		2.75e-04			2.75e-04			2.75e-04	
		(37.84%)			(39.80%)			(6.98%)	
$var(mcf(i)_t)$		6.21e-04			6.21e-04			6.21e-04	
		(62.28%)			(60.21%)			(50.97%)	
$var(dc(i)_t)$		1.92e-05			1.92e-05			4.58e-05	
		(0.00%)			(0.00%)			(42.22%)	

Note: Regression statistics are based on simulated data generated by model "Benchmark + Capacity Adjustment Friction". I examine additional idiosyncratic shocks to individual firms and calculate their responses over 10000 periods based on simulated aggregate variables. Variances are calculated based on 500 bootstrapped firms.

[a] e_t is the idiosyncratic productivity shock to individual firms.

5 Conclusion

Understanding movements of international prices lies in the heart of open macroeconomic studies. The degree of ERPT, the trade elasticity and the volatility of import price are three key measures that govern the behaviour of international prices. This paper explores the role of the dynamics of local distribution margin in explaining the connections among these three measures.

I extend Corsetti and Dedola (2005) and model distribution as an investment decision in retail capacity. The slow adjustment of retail capacity restricts the change in demand in the short-run and gives a natural explanation to the trade elasticity puzzle. I show that the trade elasticity can be decomposed into 3 channels and estimate the quantitative importance of each channel in explaining the short-run and long-run discrepancies in the trade elasticity.

The model contributes to the literature on market structures with strategic vertical and horizontal interactions. In the extended model, retailing manufacturers compete for retail resources with local retailers. The optimal decisions of retailing manufacturers depend on the responses of local retailers and non-retailing manufacturers. Since the price elasticity of demand is a function of the distribution margin, the aggregate level of ERPT and trade elasticity are sensitive to the proportion of each type of firms.

As an extension of the analysis, I investigate the role of retail capacity in explaining the empirical positive relationship between price volatility and ERPT. With the proposed model, I show analytically and quantitatively that an increase in the long-run average distribution margin reduces the correlation between price volatility and ERPT. In the short run where the retail capacity fails to adjust, ERPT of a firm is positively correlated with the volatility of its import price if (a) the size of idiosyncratic shocks is large and (b) its distribution margin is low.

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A Quantitative Performance

Table 3: Calibration

Parameters	Description	Benchmark	Calibration for the basic model
β	Discount factor	0.99	0.99
δ	Depreciation rate on retail capacity	0.025	0.025
ν	Disutility of labour	2	2
σ	Risk aversion	2	2
ρ	Elasticity of substitution between home and foreign tradable goods	2	2
ϕ	Elasticity of substitution between tradable and nontradable goods	0.74	0.74
θ_H	Elasticity of substitution within home tradable goods	15.3	15.3
θ_N	Elasticity of substitution within nontradable goods	7.7	7.7
θ_K	Elasticity of retail aggregation factor	1.4	1.4
φ_H	Effectiveness of retail capacity on distributing home products	0.3	0.3
φ_F	Effectiveness of retail capacity on distributing foreign products	0.33	0.3
ϑ	Fixed distribution cost per unit	0.5	0
Ξ	Proportion of retailing manufacturers	0.2	–
τ	Iceberg trade cost	0.03	–
γ	Frictions on retail capacity adjustment	0.00	10
ζ_1	Parameter 1 of the endogenous discount factor	-0.005	–
ζ_2	Parameter 2 of the endogenous discount factor	3	–

Note: "Benchmark + Retail Capacity Adjustment Friction" in the paper defers to the benchmark calibration with frictions on retail capacity adjustment $\gamma = 10$.

Table 4: Key statistics

Statistics	U.S. data	Benchmark	Benchmark + Retail Capacity Adjustment Friction	BKK
Business Cycle Correlations				
rGDP, Consumption	0.91	0.97	1.00	0.79
rGDP, Employment	0.85	0.89	0.99	0.94
rGDP, Investment	0.93	0.92	0.96	0.27
rGDP, Net exports	-0.69	-0.26	-0.21	-0.02
TOT, Net exports	-0.17	0.07	-0.06	-0.84
$C/C^*, REX$	-0.08	-0.01	0.00	0.98
Volatility (standard deviation) relative to rGDP				
Consumption	0.85	0.97	1.07	0.79
Employment	0.75	0.45	0.59	0.47
Investment	3.10	–	–	10.94
(a) $I_{D,H}$	–	2.79	0.49	–
(b) $I_{D,F}$	–	4.92	0.92	–
(c) I_R	–	3.20	0.76	–
Net exports	0.29	0.11	0.86	2.90
International Correlations				
$Z_{H,t}, Z_{F,t}$		0.42	0.47	0.30
$Z_{N,t}, Z^*_{N,t}$		-0.08	-0.05	–
Real GDP	0.68	0.34	0.58	-0.18
Consumption	0.46	0.29	0.65	0.88
labour	0.42	0.13	0.64	0.47
P_{import}, P_{export}	0.89	0.36	0.00	-1.00
P_{import}, REX	0.57	0.38	-0.34	-1.00
P_{export}, REX	0.58	0.33	0.85	1.00
TOT, REX	0.47	0.48	0.99	1.00
Avg. Distribtuion Margin				
Home retailing manufacturers		0.36	0.36	
Foreign retailing manufacturers at Home		0.47	0.47	
Home local retailer selling home product		0.38	0.38	
Home local retailer selling foreign product		0.38	0.38	

Note: Statistics are calculated based on logged & HP-filtered quarterly time series. The "U.S. data" column presents statistics calculated during the period 1995:1-2012:12. Data sources can be found in table 10.

Table 5: Cyclical properties

Data	*Autocorrelations*									
		(-1)	(-2)	(-3)	(-4)					
	REX	0.80	0.55	0.34	0.14					
	rGDP	0.78	0.60	0.40	0.19					
	Cross Correlations with Output									
		(-4)	(-3)	(-2)	(-1)	(0)	(+1)	(+2)	(+3)	(+4)
	Consumption	0.08	0.24	0.42	0.57	0.68	0.63	0.51	0.36	0.18
	Hours Worked	-0.20	0.01	0.29	0.55	0.73	0.75	0.67	0.56	0.45
	Investment	0.45	0.64	0.79	0.91	0.96	0.88	0.73	0.55	0.37
Benchmark Model	*Autocorrelations*									
		(-1)	(-2)	(-3)	(-4)					
	REX	0.71	0.46	0.26	0.11					
	rGDP	0.68	0.42	0.22	0.06					
	Cross Correlations with Output									
		(-4)	(-3)	(-2)	(-1)	(0)	(+1)	(+2)	(+3)	(+4)
	Consumption	0.13	0.28	0.47	0.70	0.96	0.65	0.39	0.19	0.03
	Hours Worked	0.22	0.35	0.50	0.66	0.83	0.55	0.31	0.12	-0.02
	Investment	-0.07	0.06	0.25	0.52	0.94	0.67	0.44	0.25	0.11

Note: Statistics are calculated based on logged and HP-filtered quarterly seasonal adjusted private final consumption expenditure at constant prices and gross domestic products at constant prices from periods 1995:1-2013:2. Data source: OECD Main Economic Indicators.

Table 6: Estimated ERPT from simulated data

Prices	Benchmark	
	Short Run	Long Run
P^*_{HD}	0.3794	0.4746
	(0.0062)	
P^*_{HR}	0.4594	0.5178
	(0.0047)	
P^*_{IM}	0.9406	0.9471
	(0.0005)	
P^*_{H}	0.4532	0.5153
	(0.0048)	

Note: Standard errors are reported in parentheses.

B Stylized Facts on Distribution Margin

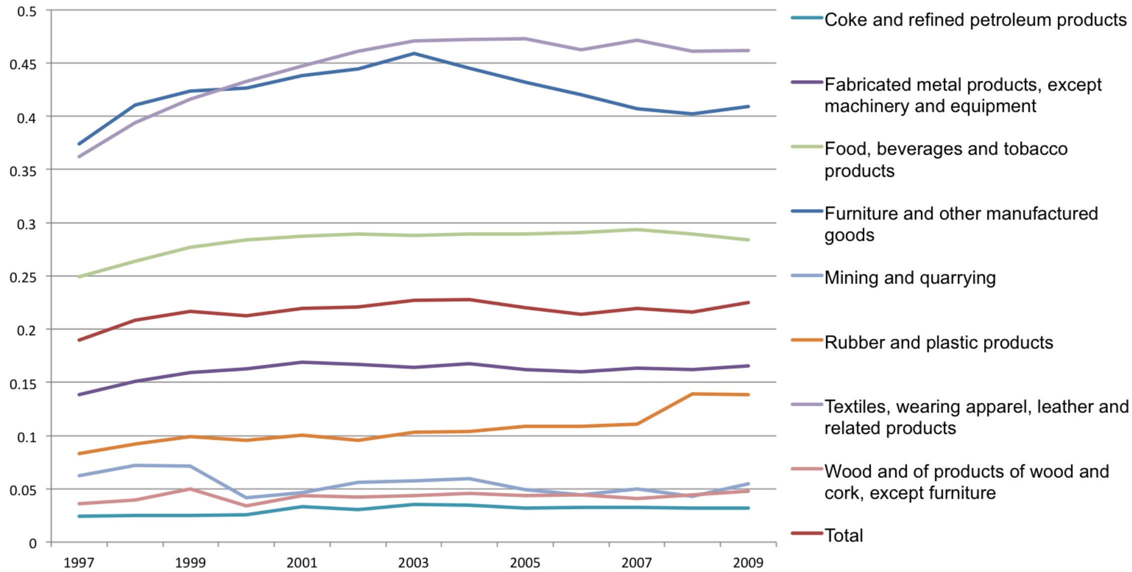
As increasing number of papers draw attention to the importance of distribution cost on interpreting EPRT, understanding the property of this local component is vital to the analysis. This section provide new evidence on distribution margin across industries and countries.

The distribution margin is estimated based on the Supply Table at current prices of the National Accounts from the Eurostat database. The data is available at the industry level at annual frequency from 1995 to 2010 for most European countries. However, this database is largely incomplete such that the relevant data for distribution margin are unavailable for most countries during the reporting periods with the exception of the year 2008. Industries are categorised by classification of products by activities (CPA) system. 65 industries including 22 goods sectors and 43 service sectors are reported in the dataset.

The dataset reports, among others, "the distribution margin and trade cost" and "the total supply at purchasers' prices". Following Goldberg and Campa (2010), the distribution margin is calculated as "the distribution margin and trade cost" divided by "the total supply at purchasers' prices". The calculated distribution margin for the UK from 1997 to 2010 is shown in Table A in the appendix. As expected, the calculated distribution margin for service sectors is close to zero. Thus, only the distribution margin for 22 goods sectors is presented[20].

[20] The aggregate distribution share (denoted as "Total") is calculated by dividing the sum of trade and distribution costs for 22 goods sectors by the sum of their total supply at purchasers' prices.

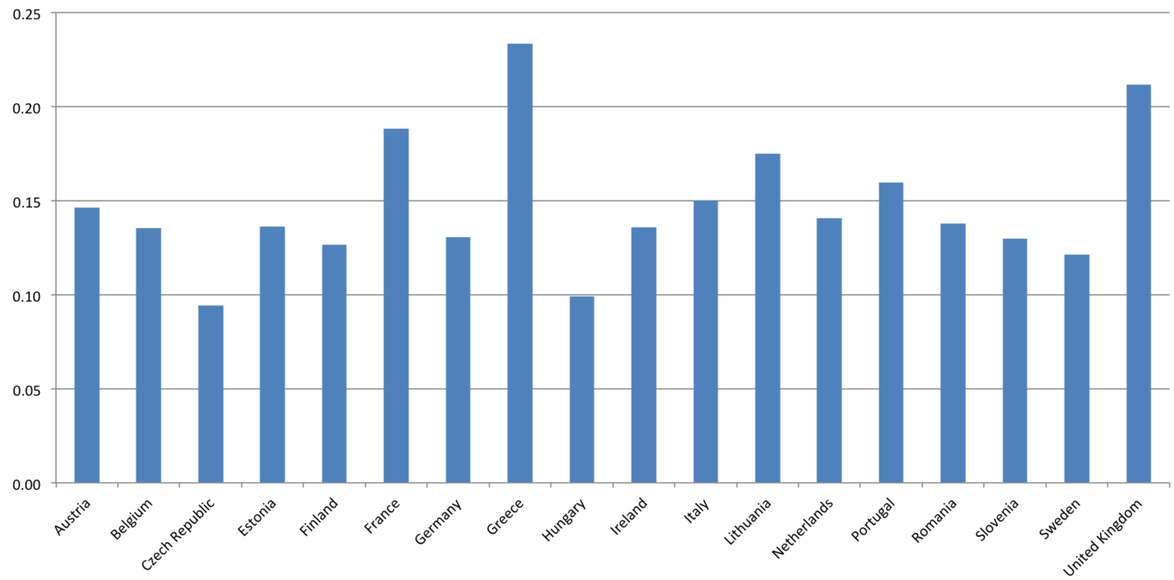
Figure 4: Estimated distribution margin of selected industries in the United Kingdom



Source: Own Calculations. Data from the "Supply Table at Current Price" under the National Account in the EUROSTAT database. Industries are categorized under the statistical classification of products by activity (CPA).

As can be seen from figure 4, there is a strong evidence on heterogeneity in distribution margin across industries. Final goods show relative bigger distribution margin compared to intermediate products and raw materials. Furnitures, textiles and wearing apparels represent the high distribution margin which ranges from 0.36 to 0.47. Food, beverages and tobacco products have a distribution margin slightly above the average (denoted with "total"). Basic energy products, such as coke and refined petroleum products, and mining and quarrying products have a relatively low distribution margin. Although the distribution share differs substantially across industries, the annual average distribution margin within the industry is relatively stable with only a small increase trend during the period from 1997 to 2010. The aggregate distribution share starts with 18.9% in 1997 and reaches 22.4% in 2010.

Figure 5: Estimated aggregate distribution margin across countries in 2008



Source: Own Calculations. Data from the "Supply Table at Current Price" under the National Account in the EUROSTAT database. Industries are categorized under the statistical classification of products by activity (CPA).

The estimated distribution margin for 18 European countries in 2008 are presented in Table B in the appendix. Figure 5 visualises the aggregate distribution margin in these countries. The estimated distribution margin of these 18 countries show strong heterogeneity across industries. A more important finding is that even in the same industry, there exist huge differences of distribution margin across countries. For instance, the most astonishing distribution margin difference lies in fish and fishing products, where the lowest distribution margin is 6.79% in Germany and highest distribution margin is as high as 61.00% in Romania. In addition, the magnitude of the difference in the industrial distribution margin across countries varies for different industries. The distribution margin difference (highest minus lowest) for food, beverages and tobacco products is only 12.92%, which is much smaller than that for fish and fishing products. The third observation is that the difference of distribution margin at aggregate level is smaller across countries compared to the industrial level. As shown in figure 5, the aggregate distribution margin of most countries lies in the range from 10% to 20%. The difference between the highest aggregate distribution margin 23.37% (Greece) and the lowest 9.43% (Czech Republic) is only 12.94%.

The differences in distribution margin may be caused by various reasons. According to the data from the Supply Table, the cost incurred by the distribution sector could be divided into two sections, namely the transportation cost to the retail store and cost involved in operating and sustaining the retail network. Distribution margins may differ for various products due to distinct inherent qualities and even for the same product due to different geographies and business structures across countries. The operating cost may differ due to country and industry specific situations, such as the related tax rate and economic conditions.

Table 7: Variances of retail price margins in the United States

Industries	Variance (%)
Food and alcohol retailing	0.0353
Health and beauty care retailing, including optical goods	0.1098
Apparel, jewellery, footwear, and accessories retailing	0.1400
Computer hardware, software, and supplies retailing	1.0974
TV, video, and photographic equipment and supplies retailing	1.0658
Automobiles and automobile parts retailing	0.0539
Manufactured (mobile) homes retailing	0.0813
RVs, trailers, and campers retailing	0.0592
Sporting goods, including boats, retailing	0.0422
Lawn, garden, and farm equipment and supplies retailing	0.0525
Furniture retailing	0.1889
Flooring and floor coverings retailing	0.1820
Hardware and building materials and supplies retailing	0.2181
Major household appliance retailing	1.6423
Fuels and lubricants retailing	1.4924
Cleaning supplies and paper products retailing	0.1188
Book retailing	0.0451
Other merchandise retailing (partial)	0.0307
All products	0.0199

Note: Statistics are calculated based on Retail Producer Price Indexes of the U.S. Bureau of Labour Statistics from 2009:3 to 2013:8.

In order to investigate the variance and correlation of distribution margin cross industries, series of monthly prices is needed. Since the Input-Output table is available on annual basis, I use sector retailer price margin series from U.S. Bureau of Labour Statistics.[21] The price margin is calculated as the current selling price minus the current acquisition price. Table 7 in the appendix presents variance calculated from percentage change of the price margin index. These variances demonstrate high degree of heterogeneity. The volatility of the aggregated retail margins (0.0019) is much smaller than that for individual sectors. However, the across sector covariance matrix of price margin changes does not show any clear pattern.

To sum up, three patterns can be extracted from data. First, distribution margins differ greatly across industries within a country. Second, while the difference in distribution margin is relatively large for the same industry across countries, this difference is much smaller at the aggregate level. Third, the variance of the retail price margin shows high degree of heterogeneity.

[21]US BLS started to release monthly sector level of retailer price indices from Jan 2009. Please see the following link for detailed description: http://www.bls.gov/opub/btn/volume-1/pdf/wholesale-and-retail-producer-price-indexes-margin-prices.pdf

C Derivations

C.1 Solve for the consumer's problem

The representative household's problem can be rewritten as:

$$U_t = \max E_t \sum_{\iota=t}^{\infty} \prod_{\varpi=t}^{\iota} \beta_{\varpi} \left\{ \begin{array}{c} \frac{1}{1-\sigma} \left[\begin{array}{c} \frac{M_{\iota+1}}{P_\iota} + (1+i_\iota) \frac{B_{H,\iota}}{P_\iota} + (1+i_\iota^*) \frac{\varepsilon_\iota B_{F,\iota}}{P_\iota} + \frac{\int_0^1 \pi_\iota(c,j)dc}{P_\iota} \\ + \frac{\int_0^1 \pi_\iota(h,j)dh}{P_\iota} + \frac{W_\iota L_\iota}{P_\iota} - \frac{T_\iota}{P_\iota} - \frac{M_\iota}{P_\iota} - \frac{B_{H,\iota+1}}{P_\iota} - \frac{\varepsilon_t B_{F,\iota+1}}{P_\iota} \end{array} \right]^{1-\sigma} \\ + \frac{1}{1-\sigma} \left(\frac{M_{\iota+1}}{P_\iota} \right)^{1-\sigma} + \alpha \frac{(1-L_\iota)^{1-\nu}}{1-\nu} \end{array} \right\}$$

First order conditions:

The Euler equation:

$B_{H,t+1}$,$B_{F,t+1}$:

$$\frac{C_t^{-\sigma}}{P_t} = \beta_t (1+i_{t+1}) E_t \left(\frac{C_{t+1}^{-\sigma}}{P_{t+1}} \right)$$

$$\frac{\varepsilon_t C_t^{-\sigma}}{P_t} = \beta_t \left(1+i_{t+1}^*\right) E_t \left(\frac{\varepsilon_{t+1} C_{t+1}^{-\sigma}}{P_{t+1}} \right)$$

Foreign counterparts:

$B_{H,t+1}^*$,$B_{F,t+1}^*$:

$$\frac{(C_t^*)^{-\sigma}}{\varepsilon_t P_t^*} = \beta_t (1+i_{t+1}) E_t \left[\frac{\left(C_{t+1}^*\right)^{-\sigma}}{\varepsilon_{t+1} P_{t+1}^*} \right]$$

$$\frac{(C_t^*)^{-\sigma}}{P_t^*} = \beta_t \left(1+i_{t+1}^*\right) E_t \left[\frac{\left(C_{t+1}^*\right)^{-\sigma}}{P_{t+1}^*} \right]$$

Optimal money holding M_{t+1} :

$$M_{t+1} = \left(\chi_t \frac{1+i_{t+1}}{i_{t+1}} \right)^{\frac{1}{\sigma}} P_t C_t$$

Labour supply L_t :

$$\frac{W_t C_t^{-\sigma}}{P_t} = \alpha (1-L_t)^{-\nu}$$

Combine the first order conditions of $B_{H,t+1}$ and $B_{H,t+1}^*$ or $B_{F,t+1}^*$ and $B_{F,t+1}$ to get the international risk sharing condition:

$$\frac{\varepsilon_t P_t^* (C_t^*)^\sigma}{P_t (C_t)^\sigma} = \frac{\beta_t E_t \left[\frac{1}{P_{t+1}(C_{t+1})^\sigma} \right]}{\beta_t^* E_t \left[\frac{1}{\varepsilon_{t+1} P_{t+1}^* \left(C_{t+1}^*\right)^\sigma} \right]} = \frac{\beta_t E_t \left[\frac{\varepsilon_{t+1}}{P_{t+1}(C_{t+1})^\sigma} \right]}{\beta_t^* E_t \left[\frac{1}{P_{t+1}^* \left(C_{t+1}^*\right)^\sigma} \right]}$$

C.2 Solve the producer's problem with quadratic investment adjustment costs

$$\max_{\left\{P_\iota^*(h_d),k_{\iota+1}^*(h_d)\right\}_{\iota=t}^\infty} \quad E_t\sum_{\iota=t}^{\infty}Q_{t,t+\iota}\left\{\begin{array}{c}\left[\varepsilon_t P_t^*(h_d)-(1+\tau)\,MC_{H,t}\right]D_t^*(h_d)\\ -\left[i_\iota^*\left(h_d\right)+\frac{\gamma\left(i_\iota^*(h_d)-\bar{i}\right)^2}{2k_\iota^*(h_d)}\right]\varepsilon_\iota P_{N,\iota}^*\end{array}\right\}$$

subject to

$$k_{t+1}^*\left(h_d\right)=i_t^*\left(h_d\right)+(1-\delta)k_t^*\left(h_d\right)-\chi_2\left(k_t^*\left(h_d\right)\right)D_t^*(h_d) \qquad \left(Q_{t,t+\iota}\varepsilon_t P_{N,\iota}^*\lambda_{1,t}^*\left(h_d\right)\right)$$

$$D_t^*(h_d)=\left(\frac{k_t^*\left(h_d\right)}{K_{H,t}^*}\right)^{\frac{1}{\theta_K}}\left(\frac{P_t^*(h_d)}{P_{H,t}^*}\right)^{-\theta_H}C_{H,t}^* \qquad \left(Q_{t,t+\iota}\varepsilon_t P_{N,\iota}^*\lambda_{2,t}^*\left(h_d\right)\right)$$

$$MC_{H,t}=\frac{W_t}{Z_{H,t}},$$

where the Lagrangian multiplier for the corresponding constraint is represented in the bracket. The optimal pricing function and its corresponding retail capacity are derived by taking first order conditions with respect to the following variables:

$P_t^*(h_d)$:

$$\varepsilon_t P_t^*(h_d)=\theta_{h_d}\varepsilon_t P_{N,t}^*\lambda_{2,t}^*\left(h_d\right)$$

$D_t^*(h_d)$:

$$\left[\varepsilon_t P_t^*(h_d)-(1+\tau)\,MC_{H,t}\right]=-P_{N,t}^*\varepsilon_t\lambda_{1,t}^*\left(h_d\right)\chi_2\left(k_t^*\left(h_d\right)\right)-\lambda_{2,t}^*\left(h_d\right)\varepsilon_t P_{N,t}^*$$

$i_\iota^*\left(h_d\right)$:

$$1+\frac{\gamma\left(i_t^*\left(h_d\right)-\bar{i}\right)}{k_t\left(h_d\right)}=-\lambda_{1,t}^*\left(h_d\right)$$

where $-\lambda_{1,t}^*\left(h_d\right)$ measures the marginal cost of adjusting capacity.

$k_{t+1}^*\left(h_d\right)$:

$$-\varepsilon_t P_{N,t}^*\lambda_{1,t}^*\left(h_d\right)=E_tQ_{t,t+1}\left\{\begin{array}{c}\varepsilon_{t+1}P_{N,t+1}^*\frac{\gamma\left(i_{t+1}^*(h_d)-\bar{i}\right)^2}{2k_{t+1}^*(h_d)^2}-\frac{\varepsilon_{t+1}P_{t+1}^*(h_d)}{\theta_H}\frac{D_{t+1}^*(h_d)}{\theta_K k_{t+1}^*(h_d)}\\ -P_{N,t+1}^*\varepsilon_{t+1}\lambda_{1,t+1}^*\left(h_d\right)\left[(1-\delta)-\chi_2'\left(k_{t+1}^*\left(h_d\right)\right)D_{t+1}^*(h_d)\right]\end{array}\right\}$$

Combine the first order conditions with respect to $P_t^*(h_d)$ and $D_t^*(h_d)$ to get the optimal price:

$$P_t^*\left(h_d\right)=\frac{\theta_H}{\theta_H-1}\left[\frac{MC_{H,t}}{\varepsilon_t}-\lambda_{1,t}^*\left(h_d\right)\chi_2(k_t^*\left(h_d\right))P_{N,t}^*\right]$$

C.3 Solve the local retailer's problem with quadratic investment adjustment costs

$$\max \quad E_t \sum_{\iota=t}^{\infty} Q_{t,t+\iota} \left\{ \begin{array}{c} \int_x^1 \left[P_\iota^*(h_r,r) - P_{im,\iota}^*(h_r,r)\right] D_\iota^*(h_r,r)dh_r + \\ \int_x^1 \left[P_\iota^*(f_r,r) - P_{local,\iota}^*(f_r,r)\right] D_\iota^*(f_r,r)df_r \\ -\left[i_\iota^*(r) + \frac{\gamma\left(i_\iota^*(r)-\bar{i}\right)^2}{2k_\iota(r)}\right] P_{N,\iota}^* \end{array} \right\}$$

subject to

$$\begin{aligned}
k_{t+1}^*(r) &= i_t^*(r) + (1-\delta)k_t^*(r) \\
&\quad - \chi_2\left(k_t^*(r)\right)\int_x^1 D_\iota^*(h_r,r)dh_r - \chi\left(k_t^*(r)\right)\int_x^1 D_\iota^*(f_r,r)df_r \quad \left(Q_{t,t+\iota}P_{N,\iota}^*\lambda_{1,t}^*(r)\right) \\
D_t^*(h_r,r) &= \left(\frac{k_t^*(r)}{K_{H,t}^*}\right)^{\frac{1}{\theta_K}} \left(\frac{P_\iota^*(h_r,r)}{P_{H,t}^*}\right)^{-\theta_H} C_{H,t}^* \quad \left(Q_{t,t+\iota}P_{N,\iota}^*\lambda_{2,t}^*(h_r,r)\right) \\
D_t^*(f_r,r) &= \left(\frac{k_t^*(r)}{K_{F,t}^*}\right)^{\frac{1}{\theta_K}} \left(\frac{P_\iota^*(f_r,r)}{P_{F,t}^*}\right)^{-\theta_H} C_{F,t}^* \quad \left(Q_{t,t+\iota}P_{N,\iota}^*\lambda_{2,t}^*(f_r,r)\right),
\end{aligned}$$

where the Lagrangian multiplier for the corresponding constraint is represented in the bracket. The optimal pricing function and its corresponding retail capacity are derived by taking first order conditions with respect to the following variables:

$P_t^*(h_r,r)$:

$$P_t^*(h_r,r) = \theta_H P_{N,\iota}^*\lambda_{2,t}^*(h_r,r)$$

$P_t^*(f_r,r)$:

$$P_t^*(f_r,r) = \theta_H \varepsilon_t P_{N,t}^*\lambda_{2,t}^*(f_r,r)$$

$D_t^*(h_r,r)$:

$$\left[P_t^*(h_r,r) - P_{im,t}^*(h_r,r)\right] = -P_{N,t}^*\lambda_{1,t}^*(r)\chi_2\left(k_t^*(h_r,r)\right) - \lambda_{2,t}^*(h_r,r)P_{N,t}^*$$

$D_t^*(f_r,r)$:

$$\left[P_t^*(f_r,r) - P_{local,t}^*(f_r,r)\right] = -P_{N,t}^*\lambda_{1,t}^*(r)\chi\left(k_t^*(f_r,r)\right) - \lambda_{2,t}^*(f_r,r)P_{N,t}^*$$

$i_\iota^*(r)$:

$$1 + \frac{\gamma\left(i_t^*(r) - \bar{i}\right)}{k_t(r)} = -\lambda_{1,t}^*(r)$$

$k_{t+1}^*(r)$:

$$-P_{N,t}^*\lambda_{1,t}^*(r) = E_t Q_{t,t+1}\left\{\begin{array}{c} P_{N,t+1}^*\frac{\gamma\left(i_{t+1}^*(r)-\bar{i}\right)^2}{2k_{t+1}^*(r)^2} - \int_x^1 \frac{P_{t+1}^*(h_r,r)}{\theta_H}\frac{D_{t+1}^*(h_r,r)}{\theta_K k_{t+1}^*(r)}dh_r \\ -\int_x^1 \frac{P_{t+1}^*(f_r,r)}{\theta_H}\frac{D_{t+1}^*(f_r,r)}{\theta_K k_{t+1}^*(r)}df_r - P_{N,t+1}^*\lambda_{1,t+1}^*(r)(1-\delta) \\ P_{N,t+1}^*\lambda_{1,t+1}^*(r)\left[\begin{array}{c}\chi_2'\left(k_{t+1}^*(r)\right)\int_x^1 D_{t+1}^*(h_r,r)dh_r \\ +\chi'\left(k_{t+1}^*(r)\right)\int_x^1 D_{t+1}^*(f_r,r)df_r\end{array}\right]\end{array}\right\}$$

Combine the first order conditions with respect to $P_t^*(h)$ and $D_t^*(h)$ to get the optimal price:

$$P_t^*(h_r,r) = \frac{\theta_H}{\theta_H-1}\left[P_{im,t}(h_r,r) - \lambda_{1,t}^*(r)\,\chi_2(k_t^*(h_r,r))P_{N,t}^*\right]$$

C.4 Aggregations and resource constraints

Aggregate consumptions, retail capacity and prices are aggregated in the same way as in the basic model. The only difference is that we need to take into account the proportion of two groups of firms.

$$\begin{aligned}
C_{H,t} &\equiv \left[\int_0^x \left(\frac{k_t(h_d)}{K_{H,t}}\right)^{\frac{1}{\theta_H\theta_K}} C_t(h_d)^{\frac{\theta_H-1}{\theta_H}}\,dh_d + \int_x^1 \left(\frac{k_t(h_r)}{K_{H,t}}\right)^{\frac{1}{\theta_H\theta_K}} C_t(h_r)^{\frac{\theta_H-1}{\theta_H}}\,dh_r\right]^{\frac{\theta_H}{\theta_H-1}} \\
C_{F,t} &\equiv \left[\int_0^x \left(\frac{k_t(f_d)}{K_{F,t}}\right)^{\frac{1}{\theta_H\theta_K}} C_t(f_d)^{\frac{\theta_H-1}{\theta_H}}\,df_d + \int_x^1 \left(\frac{k_t(f_r)}{K_{F,t}}\right)^{\frac{1}{\theta_H\theta_K}} C_t(f_r)^{\frac{\theta_H-1}{\theta_H}}\,df_r\right]^{\frac{\theta_H}{\theta_H-1}} \\
K_{H,t} &\equiv \left[\int_0^x k_t(h_d)^{\frac{1}{\theta_K}}\,dh_d + \int_x^1 k_t(h_r)^{\frac{1}{\theta_K}}\,dh_r\right]^{\theta_K}, \\
K_{F,t} &\equiv \left[\int_0^x k_t(f_d)^{\frac{1}{\theta_K}}\,df_d + \int_x^1 k_t(f_r)^{\frac{1}{\theta_K}}\,df_r\right]^{\theta_K} \\
P_{H,t} &= \left[\int_0^x \left(\frac{k_t(h_d)}{K_{H,t}}\right)^{\frac{1}{\theta_K}} p_t(h_d)^{1-\theta_H}\,dh_d + \int_x^1 \left(\frac{k_t(h_r)}{K_{H,t}}\right)^{\frac{1}{\theta_K}} p_t(h_r)^{1-\theta_H}\,dh_r\right]^{\frac{1}{1-\theta_H}}, \\
P_{F,t} &= \left[\int_0^x \left(\frac{k_t(f_d)}{K_{F,t}}\right)^{\frac{1}{\theta_K}} p_t(f_d)^{1-\theta_H}\,df_d + \int_x^1 \left(\frac{k_t(f_r)}{K_{F,t}}\right)^{\frac{1}{\theta_K}} p_t(f_r)^{1-\theta_H}\,df_r\right]^{\frac{1}{1-\theta_H}}
\end{aligned}$$

At the aggregate level the investment of the retail capacity for home tradables $I_{DH,t}$, home retailers $I_{R,t}$ and foreign tradables $I_{DF,t}$ are given by:

$$\begin{aligned} I_{DH,t} &= \int_0^x \left[k_{t+1}(h_d) + \chi(k_t(h_d))C_t(h_d) - (1-\delta)k_t(h_d)\right] dh_d \\ I_{DF,t} &= \int_0^x \left[k_{t+1}(f_d) + \chi_2(k_t(f_d))C_t(f_d) - (1-\delta)k_t(f_d)\right] df_d \\ I_{R,t} &= K_{R,t+1} + \chi_2(K_{R,t})C_{FR,t} + \chi(K_{R,t})C_{HR,t} - (1-\delta)K_{R,t} \end{aligned}$$

The demand for nontradable goods is consumer demand for the nontradables plus the sum of the investment of retail capacity for home tradables and foreign tradables.

$$D_t(n) = \left(\frac{p_t(n)}{P_{N,t}}\right)^{-\theta_N} \left[C_{N,t} + I_{DF,t} + I_{DH,t} + I_{R,t}\right]$$

The optimal price is given by

$$p_t(n) = P_{N,t} = \frac{\theta_N}{\theta_N - 1} MC_{N,t}$$

From the aggregate resource constraint, the aggregate labour used is equal to the per unit labour cost times the total quantity produced.

$$L_t = \frac{Y_{N,t}}{Z_{N,t}} + \frac{Y_{H,t}}{Z_{H,t}} = \frac{I_{DH,t} + I_{DF,t} + I_{R,t} + C_{N,t}}{Z_{N,t}} + \frac{C_{H,t} + C_{H,t}^*}{Z_{H,t}}$$

C.5 The current account

The stochastic discount factor $Q_{t,t+1}$ is defined such that the expectation of this discount factor is just the inverse of the nominal interest rate[22].

$$Q_{t,t+1} \equiv \beta_t \frac{P_t C_t^\sigma}{P_{t+1} C_{t+1}^\sigma}, EQ_{t,t+1} = \frac{1}{1+i_{t+1}}, E\left[Q_{t,t+1}\frac{\varepsilon_{t+1}}{\varepsilon_t}\right] = \frac{1}{1+i_{t+1}^*}$$

The following three equations describe the equilibrium conditions of the international bond holding and balance of the current account.

$$B_{H,t} = -B_{H,t}^*, \quad B_{F,t} = -B_{F,t}^*$$

$$\overline{A_t} \equiv A_{t+1} - M_t = B_{H,t} + \varepsilon_t B_{F,t} = -\, B_{H,t}^* - \varepsilon_t B_{F,t}^* = -\varepsilon_t \left(\frac{B_{H,t}^*}{\varepsilon_t} + B_{F,t}^*\right) = -\varepsilon_t \overline{A_t^*}$$

When calculating the price of imports and exports, I subtract the distribution cost from the

[22] See the first order condition of the nominal bond holding for the consumer's optimisation problem in the appendix.

consumer price for the price of direct exporters.

$$\begin{aligned} NX_t &= \varepsilon_t \left(P^*_{HD,t} - \chi_2\left(K^*_{HD,t+1}\right)P^*_{N,t}\right)C^*_{HD,t} + \varepsilon_t P^*_{IM,t}C^*_{HR,t} \\ &\quad - \left(P_{FD,t} - \chi_2\left(K_{FD,t+1}\right)P_{N,t}\right)C_{FD,t} - P_{IM,t}C_{FR,t} \end{aligned}$$

The balance of trade is simply adding the net export to the capacity account.

$$E_t\left\{Q_{t,t+1}\overline{A}_{t+1}\right\} = \overline{A}_t + NX_t$$

D Summary of Equilibrium Conditions

The world equilibrium is characterised as follows. Given the strict inflation targeting monetary policy, the stochastic process of the productivity shock, and the initial conditions of bond holding and money holding, the equilibrium is given by the above set of endogenous variables which satisfy (a) the consumer's optimisation constraints such that home and foreign representative households maximise their utility; (b) producers' optimal price choice and retailers' optimal capacity choice such that producers and retailers in the home and foreign country maximise their profit; (c) market clear constraints and (d) aggregate resource constraints. The summary of equilibrium conditions of the home country is given as follows, the corresponding foreign equilibrium conditions can be easily derived:

Table 8: Summary of equilibrium conditions

Endogenous discount factor of consumer preference:	$\beta_t \equiv \log\left\{\zeta_2\left[1+\zeta_1\left(C_t+\alpha\left(1-L_t\right)\right)\right]\right\}$
Definition of the stochastic discount factor:	$Q_{t,t+1} \equiv \beta_t \frac{P_t C_t^{\sigma}}{P_{t+1}C_{t+1}^{\sigma}}$
Accounting identity for retail capacity investment:	$I_{HD,t} = K_{HD,t+1} + \chi(K_{HD,t})C_{HD,t} - (1-\delta)K_{HD,t}$ $I_{FD,t} = K_{FD,t+1} + \chi_2(K_{FD,t})C_{FD,t} - (1-\delta)K_{FD,t}$ $I_{R,t} = K_{R,t+1} + \chi(K_{R,t})C_{HR,t} + \chi_2(K_{R,t})C_{FR,t} - (1-\delta)K_{R,t}$

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Table 8: Summary of equilibrium conditions – continued

Aggregate resource constraint:	$L_t = \frac{Y_{N,t}}{Z_{N,t}} + \frac{Y_{H,t}}{Z_{H,t}} = \frac{I_{HD,t}+I_{FD,t}+I_{R,t}+C_{N,t}}{Z_{N,t}} + \frac{C_{H,t}+C^*_{H,t}(1+\tau)}{Z_{H,t}}$
Labour equilibrium:	$\frac{W_t C_t^{-\sigma}}{P_t} = \alpha \left(1 - L_t\right)^{-\nu}$
Retail capacity aggregation:	$K_{H,t} \equiv \left[x K_{HD,t}^{\frac{1}{\theta_K}} + (1-x) K_{R,t}^{\frac{1}{\theta_K}} \right]^{\theta_K}$, $K_{F,t} \equiv \left[x K_{FD,t}^{\frac{1}{\theta_K}} + (1-x) K_{R,t}^{\frac{1}{\theta_K}} \right]^{\theta_K}$
Retail market share:	$S_{H,t} = \frac{\left(K_{H,t}\right)^{\frac{1}{\theta_K}}}{\left(K_{H,t}\right)^{\frac{1}{\theta_K}} + \left(K_{F,t}\right)^{\frac{1}{\theta_K}}}, S_{F,t} = \frac{\left(K_{F,t}\right)^{\frac{1}{\theta_K}}}{\left(K_{H,t}\right)^{\frac{1}{\theta_K}} + \left(K_{F,t}\right)^{\frac{1}{\theta_K}}}$ $S_{HD,t} = \left(\frac{K_{HD,t}}{K_{H,t}}\right)^{\frac{1}{\theta_K}}, S_{FD,t} = \left(\frac{K_{FD,t}}{K_{F,t}}\right)^{\frac{1}{\theta_K}}$
Consumer's demand:	$C_{N,t} = \left(\frac{P_{N,t}}{P_t}\right)^{-\phi} C_t, C_{T,t} = \left(\frac{P_{T,t}}{P_t}\right)^{-\phi} C_t$ $C_{H,t} = S_{H,t} \left(\frac{P_{H,t}}{P_{T,t}}\right)^{-\rho} C_{T,t}, C_{F,t} = S_{F,t} \left(\frac{P_{F,t}}{P_{T,t}}\right)^{-\rho} C_{T,t}$ $C_{HD,t} = x S_{HD,t} \left(\frac{P_{HD,t}}{P_{H,t}}\right)^{-\rho} C_{H,t}, C_{FD,t} = x S_{FD,t} \left(\frac{P_{FD,t}}{P_{F,t}}\right)^{-\rho} C_{F,t}$ $C_{HR,t} = (1-x)\left(1 - S_{HD,t}\right) \left(\frac{P_{HR,t}}{P_{H,t}}\right)^{-\theta_H} C_{H,t},$ $C_{FR,t} = (1-x)\left(1 - S_{FD,t}\right) \left(\frac{P_{FR,t}}{P_{F,t}}\right)^{-\theta_H} C_{F,t}$
Price aggregation:	$P_{T,t} = \left[S_{H,t} P_{H,t}^{1-\rho} + S_{F,t} P_{F,t}^{1-\rho} \right]^{\frac{1}{1-\rho}}, P_t = \left[P_{T,t}^{1-\phi} + P_{N,t}^{1-\phi} \right]^{\frac{1}{1-\phi}}$ $P_{H,t} = \left[x S_{HD,t} P_{HD,t}^{1-\theta_H} + (1-x)\left(1 - S_{HD,t}\right) P_{HR,t}^{1-\theta_H} \right]^{\frac{1}{1-\theta_H}}$ $P_{F,t} = \left[x S_{FD,t} P_{FD,t}^{1-\theta_H} + (1-x)\left(1 - S_{FD,t}\right) P_{FR,t}^{1-\theta_H} \right]^{\frac{1}{1-\theta_H}}$

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Table 8: Summary of equilibrium conditions – continued

Current account:

$$E_t\left\{Q_{t,t+1}\overline{A}_{t+1}\right\} = \overline{A}_t + CA_t$$

$$CA_t = \varepsilon_t\left(P^*_{HD,t} - \chi_2\left(K^*_{HD,t+1}\right)\right)C^*_{HD,t} + \varepsilon_t P^*_{IM,t}C^*_{HR,t} - \left(P_{FD,t} - \chi_2\left(K_{FD,t+1}\right)\right)C_{FD,t} - P_{IM,t}C_{FR,t}$$

International risk sharing condition:

$$\frac{\varepsilon_t P^*_t (C^*_t)^{\sigma}}{P_t(C_t)^{\sigma}} = \frac{\beta_t E_t\left[\frac{1}{P_{t+1}(C_{t+1})^{\sigma}}\right]}{\beta^*_t E_t\left[\frac{1}{\varepsilon_{t+1}P^*_{t+1}\left(C^*_{t+1}\right)^{\sigma}}\right]} = \frac{\beta_t E_t\left[\frac{\varepsilon_{t+1}}{P_{t+1}(C_{t+1})^{\sigma}}\right]}{\beta^*_t E_t\left[\frac{1}{P^*_{t+1}\left(C^*_{t+1}\right)^{\sigma}}\right]}$$

Optimal retail capacity:

$$-P_{N,t}\lambda^R_{1,t} = E_tQ_{t,t+1}\left\{\begin{array}{c} P_{N,t+1}\frac{\gamma\left(I_{R,t+1}-\bar{i}\right)^2}{2K_{R,t+1}{}^2} - \frac{P_{HR,t+1}}{\theta_H}\frac{D_{HR,t+1}}{\theta_K K_{R,t+1}} \\ -\frac{P_{FR,t+1}}{\theta_H}\frac{D_{FR,t+1}}{\theta_K K_{R,t+1}} - P_{N,t+1}\lambda^R_{1,t+1}(1-\delta) \\ P_{N,t+1}\lambda^R_{1,t+1}\left[\begin{array}{c}\chi'\left(K_{R,t+1}\right)D_{HR,t+1} \\ +\chi'_2\left(K_{R,t+1}\right)D_{FR,t+1}\end{array}\right]\end{array}\right\}$$

$$-\frac{P_{N,t}\lambda^{FD}_{1,t}}{\varepsilon_t} = E_tQ_{t,t+1}\left\{\begin{array}{c} \frac{P_{N,\iota+1}}{\varepsilon_{t+1}}\frac{\gamma\left(I_{FD,t+1}-\overline{I}_{FD}\right)^2}{2(K_{FD.t+1})^2} - \frac{P_{FD,t+1}}{\varepsilon_{t+1}\theta_H}\frac{C_{FD,t+1}}{\theta_K K_{FD,t+1}} \\ -\frac{P_{N,t+1}\lambda^{FD}_{1,t+1}}{\varepsilon_{t+1}}\left[(1-\delta) - \chi'_2\left(K_{FD,t+1}\right)C_{FD,t+1}\right]\end{array}\right\}$$

$$-P_{N,t}\lambda^{HD}_{1,t} = E_tQ_{t,t+1}\left\{\begin{array}{c} P_{N,\iota+1}\frac{\gamma\left(I_{HD,t+1}-\overline{I}_{HD}\right)^2}{2(K_{HD.t+1})^2} - \frac{P_{HD,t+1}}{\theta_H}\frac{C_{HD,t+1}}{\theta_K K_{HD,t+1}} \\ -P_{N,t+1}\lambda^{HD}_{1,t+1}\left[(1-\delta) - \chi'\left(K_{HD,t+1}\right)C_{HD,t+1}\right]\end{array}\right\}$$

$$1 + \frac{\gamma\left(I_{FD,t}-\overline{I}_{FD}\right)}{K_{FD,t}} = -\lambda^{FD}_{1,t}$$

$$1 + \frac{\gamma\left(I_{HD,t}-\overline{I}_{HD}\right)}{K_{HD,t}} = -\lambda^{HD}_{1,t}$$

$$1 + \frac{\gamma\left(I_{R,t}-\overline{I}_{R}\right)}{K_{R,t}} = -\lambda^{R}_{1,t}$$

Optimal price setting:

$$P_{FD,t} = \frac{\theta_H}{\theta_H - 1}\left[\varepsilon_t MC_{F,t}(1+\tau) - \lambda^{FD}_{1,t}\chi_2(K_{FD,t})P_{N,t}\right]$$

Continued on next page...

Table 8: Summary of equilibrium conditions – continued

	$P_{HD,t} = \frac{\theta_H}{\theta_H - 1}\left[MC_{H,t} - \lambda_{1,t}^{HD}\chi(K_{HD,t})P_{N,t}\right]$
	$P_{HR,t} = \frac{\theta_H}{\theta_H - 1}\left[P_{L,t} - \lambda_{1,t}^{R}\chi(K_{R,t})P_{N,t}\right]$
	$P_{FR,t} = \frac{\theta_H}{\theta_H - 1}\left[P_{IM,t} - \lambda_{1,t}^{R}\chi_2(K_{R,t})P_{N,t}\right]$
	$P_{L,t} = \frac{\theta_H}{\theta_H - 1}\left[MC_{H,t} - \frac{1}{\theta_H}\lambda_{1,t}^{R}\chi(K_{R,t})P_{N,t}\right]$
	$P_{IM,t} = \frac{\theta_H}{\theta_H - 1}\left[\varepsilon_t MC_{F,t}\left(1+\tau\right) - \frac{1}{\theta_H}\lambda_{1,t}^{R}\chi_2(K_{R,t})P_{N,t}\right]$
	$P_{N,t} = \frac{\theta_N}{\theta_N - 1}MC_{N,t}$
Marginal costs:	$MC_{N,t} = \frac{W_t}{Z_{N,t}}, MC_{H,t} = \frac{W_t}{Z_{H,t}}$

Table 9: List of aggregate variables

Variables	Description	Simulation Form
ε_t	Nominal exchange rate	q
P_t	CPI	p
$P_{T,t}$	Price index of tradable goods	pt
$P_{F,t}$	Consumer price index of imports	pf
$P_{H,t}$	Consumer price index of home produced goods	ph
$P_{N,t}$	Price index of nontradable goods	pn
$P_{HD,t}$	Consumer price of goods produced by home retailing manufacturers (Subscript D means distributing by itself)	phd
$P_{HR,t}$	Consumer price of goods produced by home non-retailing manufacturers (Subscript R means selling to local retailer)	phr
$P_{FD,t}$	Consumer price of goods imported from foreign retailing manufacturers (Subscript D means distributing by itself)	pfd
$P_{FR,t}$	Consumer price of goods imported from foreign non-retailing manufacturers (Subscript R means selling to local retailer)	pfr
$P_{L,t}$	Wholesale price of goods produced by home retailing manufacturers	pl
$P_{IM,t}$	Wholesale price of goods produced by home non-retailing manufacturers	pim
C_t	Aggregate consumption	c
$C_{T,t}$	Consumptions of tradable goods	ct
$C_{H,t}$	Consumptions of home produced goods	ch
$C_{F,t}$	Consumptions of imports	cf
$C_{N,t}$	Consumptions of nontradable goods	cn
$C_{HD,t}$	Consumptions of goods produced by home retailing manufacturers	chd
$C_{HR,t}$	Consumptions of goods produced by home non-retailing manufacturers	chr
$C_{FD,t}$	Consumptions of goods imported from foreign retailing manufacturers	cfd
$C_{FR,t}$	Consumptions of goods imported from foreign non-retailing manufacturers	cfr
$MC_{N,t}$	Marginal cost of nontradable good producers	mcn
$MC_{H,t}$	Marginal cost of domestic tradable good producers	mch
$K_{HD,t}$	retail capacity of home retailing manufacturers	kdh
$K_{FD,t}$	retail capacity of foreign retailing manufacturers	kdf
$K_{R,t}$	retail capacity of retailers	kr
$I_{HD,t}$	Investment made by home retailing manufacturers	idh
$I_{FD,t}$	Investment made by foreign retailing manufacturers	idf
$I_{R,t}$	Investment made by retailers	ir
L_t	Equilibrium employment	l
W_t	Nominal wage	w
$Q_{t,t+1}$	Stochastic discount factor	dis
$\overline{A}_t$	Net international bond holding	a
REX_t	Real exchange rate $\equiv \frac{\varepsilon_t P_t^*}{P_t}$	rex
TOT_t	Terms of trade $\equiv \frac{\overline{P}_{F,t}}{\varepsilon_t \overline{P}^*_{H,t}}$	tot

Note: This list presents the simulation form of home variables. The simulation forms of relative prices are measure by the foreign variable over the home variable. Simulation forms of foreign variables are denoted with a suffix "s".

Table 10: Data sources

Series	Frequency	Periods	Source
Export, Import Prices of the United States	Quarterly	1990:1-2013:2	Export/import price index all commodities, the U.S. Bureau of Labour Statistics
Real Effective Exchange Rate; Bilateral Nominal Exchange Rate	Quarterly; Monthly	1990:1-2013:2	International Financial Statistics, IMF
Terms of Trade	Quarterly	1990:1-2013:2	Datastream
Business Cycle Series: Consumption, Investment, Total Hours Worked, Net Exports	Quarterly	1995:1-2013:2	OECD Main Economic Indicators; OECD Economic Outlook
Distribution Margins	Annual	1995-2010	Supply Table at current prices of the National Accounts, Eurostat Database
Sectoral Retail Price Margins	Monthly	2009:3-2013:8	The U.S. Bureau of Labour Statistics
Bilateral Import/Export Unit Value Indices	Monthly	1995:1-2001:12	COMEXT (Eurostat) Database

Table A: The Estimated Distribution Margin in the Uinted Kingdom from 1997 to 2009

Industries \ Year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Max	Min	Average
Basic metals	0.1655	0.1757	0.2003	0.1608	0.1675	0.1613	0.1590	0.1791	0.1667	0.1549	0.1553	0.1715	0.1475	0.2003	0.1475	0.1665
Basic pharmaceutical products and pharmaceutical preparations	0.2420	0.2663	0.2759	0.2688	0.2781	0.2728	0.2783	0.2732	0.2694	0.2677	0.2586	0.2514	0.2426	0.2783	0.2420	0.2650
Chemicals and chemical products	0.1980	0.2270	0.2399	0.2421	0.2349	0.2404	0.2503	0.2447	0.2375	0.2365	0.2330	0.2393	0.2428	0.2503	0.1980	0.2359
Coke and refined petroleum products	0.0240	0.0247	0.0250	0.0253	0.0331	0.0305	0.0355	0.0349	0.0319	0.0329	0.0324	0.0319	0.0321	0.0355	0.0240	0.0303
Computer, electronic and optical products	0.1860	0.2044	0.2046	0.1915	0.1970	0.1923	0.2091	0.2181	0.1957	0.1737	0.2364	0.2293	0.2389	0.2389	0.1737	0.2059
Electrical equipment	0.2152	0.2370	0.2312	0.2293	0.2488	0.2435	0.2455	0.2470	0.2421	0.2384	0.2324	0.2378	0.2455	0.2488	0.2152	0.2380
Fabricated metal products	0.1382	0.1509	0.1596	0.1626	0.1689	0.1666	0.1645	0.1677	0.1624	0.1600	0.1635	0.1617	0.1656	0.1689	0.1382	0.1609
Fish and other fishing products; aquaculture products;	0.1557	0.1727	0.1920	0.1833	0.1873	0.1796	0.1795	0.1742	0.1618	0.1546	0.1384	0.1321	0.1340	0.1920	0.1321	0.1650
Food, beverages and tobacco products	0.2492	0.2636	0.2769	0.2842	0.2876	0.2892	0.2878	0.2893	0.2893	0.2911	0.2936	0.2893	0.2841	0.2936	0.2492	0.2827
Furniture and other manufactured goods	0.3741	0.4103	0.4236	0.4268	0.4383	0.4446	0.4592	0.4450	0.4318	0.4201	0.4068	0.4023	0.4092	0.4592	0.3741	0.4225
Machinery and equipment n.e.c.	0.1063	0.1215	0.1305	0.1288	0.1334	0.1350	0.1403	0.1425	0.1377	0.1354	0.1106	0.1056	0.1161	0.1425	0.1056	0.1264
Mining and quarrying	0.0622	0.0720	0.0711	0.0417	0.0463	0.0561	0.0575	0.0597	0.0489	0.0443	0.0501	0.0430	0.0547	0.0720	0.0417	0.0544
Motor vehicles, trailers and semi-trailers	0.1680	0.1878	0.1980	0.1990	0.2050	0.1841	0.1874	0.1898	0.1959	0.1974	0.1978	0.2258	0.2742	0.2742	0.1680	0.2008
Other non-metallic mineral products	0.1762	0.1912	0.2027	0.2012	0.2096	0.2052	0.2108	0.2276	0.2226	0.2186	0.2191	0.2274	0.2200	0.2276	0.1762	0.2102
Other transport equipment	0.0457	0.0518	0.0572	0.0530	0.0539	0.0530	0.0587	0.0603	0.0525	0.0494	0.0460	0.0443	0.0408	0.0603	0.0408	0.0513
Paper and paper products	0.2379	0.2451	0.2613	0.2580	0.2644	0.2778	0.2810	0.2863	0.2916	0.2897	0.2843	0.2946	0.3034	0.3034	0.2379	0.2750
Products of agriculture, hunting and related services	0.1258	0.1409	0.1518	0.1631	0.1608	0.1553	0.1488	0.1493	0.1440	0.1444	0.1454	0.1389	0.1446	0.1631	0.1258	0.1472
Products of forestry, logging and related services	0.1746	0.1739	0.1777	0.1858	0.1819	0.1772	0.1707	0.1689	0.1622	0.1573	0.1602	0.1653	0.1663	0.1858	0.1573	0.1709
Rubber and plastic products	0.0829	0.0920	0.0992	0.0957	0.1002	0.0954	0.1034	0.1042	0.1085	0.1084	0.1106	0.1389	0.1383	0.1389	0.0829	0.1060
Textiles, wearing apparel, leather and related products	0.3620	0.3939	0.4163	0.4330	0.4475	0.4610	0.4709	0.4720	0.4730	0.4622	0.4716	0.4613	0.4620	0.4730	0.3620	0.4451
Wood and of products of wood and cork	0.0358	0.0397	0.0501	0.0340	0.0438	0.0423	0.0440	0.0459	0.0436	0.0442	0.0408	0.0447	0.0479	0.0501	0.0340	0.0428
Total	0.1896	0.2082	0.2171	0.2127	0.2196	0.2211	0.2273	0.2281	0.2201	0.2141	0.2195	0.2159	0.2247	0.2281	0.1896	0.2168

Source: Own Calculations. Data from the Supply Table at current price under the National Account in the EUROSTAT database. Industries are categorized under the statistical classification of products by activity (CPA).

Table B: The Estimated Distribution Margin Across Countries in 2008

Industries \ Countries	Austria	Belgium	Czech Republic	Estonia	Finland	France	Germany	Greece	Hungary	Ireland	Italy	Lithuania	Netherlands	Portugal	Romania	Slovenia	Sweden	United Kingdom	Max	Min	Average
Basic metals	0.0446	0.0804	0.0427	0.0644	0.0103	0.0618	0.0492	0.1526	0.0884	0.0661	0.0501	0.0804	0.0575	0.0880	0.0681	0.0484	0.0774	0.1715	0.1715	0.0103	0.0723
Basic pharmaceutical products and pharmaceutical preparations	0.3179	0.2139	0.1336	0.2173	0.2976	0.3507	0.2776	0.2985	0.1841	0.0539	0.2711	0.3264	0.2174	0.3370	0.1867	0.1690	NA	0.2514	0.3507	0.0539	0.2414
Chemicals and chemical products	0.1451	0.1180	0.1121	0.1503	0.1103	0.1860	0.1037	0.2588	0.0999	0.0989	0.1208	0.1162	0.0906	0.1593	0.1436	0.1003	0.1445	0.2393	0.2588	0.0906	0.1388
Coke and refined petroleum products	0.1669	0.0518	0.1229	0.1336	0.0579	0.1021	0.0636	0.1221	0.0930	0.1981	0.1089	NA	0.0415	0.1443	0.2336	0.1217	0.0798	0.0319	0.2336	0.0319	0.1102
Computer, electronic and optical products	0.1852	0.1976	0.0553	0.0890	0.0800	0.2143	0.1630	0.3012	0.0346	0.0043	0.2088	0.2646	0.1886	0.1273	0.1473	0.1897	0.0909	0.2293	0.3012	0.0043	0.1539
Electrical equipment	0.1190	0.1986	0.0624	0.0650	0.1219	0.1757	0.1312	0.2835	0.0671	0.0321	0.1124	0.0932	0.1914	0.1296	0.0544	0.0846	0.1086	0.2378	0.2835	0.0321	0.1260
Fabricated metal products	0.1059	0.1042	0.0712	0.0938	0.0817	0.1269	0.0898	0.2467	0.0798	0.0090	0.0893	0.2211	0.1150	0.0965	0.0643	0.1016	0.0777	0.1617	0.2467	0.0090	0.1076
Fish and other fishing products; aquaculture products;	0.2962	0.2635	NA	0.0892	0.1837	0.4529	0.0679	0.2729	0.1936	0.2993	0.3985	0.3882	0.3628	0.5059	0.6100	0.3260	0.1452	0.1321	0.6100	0.0679	0.2934
Food, beverages and tobacco products	0.2084	0.1761	0.1886	0.1800	0.2730	0.2429	0.2099	0.2527	0.2025	0.2084	0.2202	0.2801	0.1601	0.2480	0.2145	0.2348	0.2120	0.2893	0.2893	0.1601	0.2223
Furniture and other manufactured goods	0.2674	0.1775	0.1184	0.2108	0.3203	0.3640	0.2410	0.2711	0.2157	NA	0.2566	0.2191	0.2596	0.2831	0.2771	0.1826	0.2116	0.4023	0.4023	0.1184	0.2517
Machinery and equipment n.e.c.	0.1033	0.1697	0.0740	0.0982	0.0418	0.1837	0.0609	0.1682	0.0855	0.3553	0.0852	0.1744	0.1542	0.1123	0.0844	0.0870	0.1199	0.1056	0.3553	0.0418	0.1258
Mining and quarrying	0.0694	0.0475	0.0431	0.0861	0.0423	0.0439	0.1630	0.1750	0.0538	0.0418	0.0490	0.0535	0.0204	0.0167	0.1028	0.1682	0.0475	0.0430	0.1750	0.0167	0.0704
Motor vehicles, trailers and semi-trailers	0.0918	0.0996	0.0758	0.1529	0.1349	0.1638	0.0779	0.4620	0.0675	0.2590	0.1367	0.2083	0.1139	0.0819	0.1322	0.0892	0.0779	0.2258	0.4620	0.0675	0.1473
Other non-metallic mineral products	0.1552	0.1884	0.0908	0.2049	0.2015	0.2595	0.1610	0.1692	0.1305	0.1990	0.1428	0.2373	0.2309	0.0869	0.1407	0.2373	0.1469	0.2274	0.2595	0.0869	0.1784
Other transport equipment	0.0325	0.1278	0.0156	0.1410	0.0438	0.0273	0.0492	0.1872	0.1051	0.0385	0.0885	0.2515	0.0887	0.0645	0.0384	0.1051	0.0636	0.0443	0.2515	0.0156	0.0841
Paper and paper products	0.1096	0.1674	0.0983	0.1125	0.0727	0.1409	0.1181	0.2740	0.1565	0.1811	0.0958	0.1181	0.1785	0.1356	0.0752	0.0703	0.1026	0.2946	0.2946	0.0703	0.1390
Printing and recording services	0.0008	0.1474	0.0980	NA	0.1951	0.1237	0.0032	0.1539	0.0244	0.1050	0.0013	0.2130	0.0117	0.0096	0.0134	0.0013	0.0093	NA	0.2130	0.0008	0.0694
Products of agriculture, hunting and related services	0.1648	0.2123	0.0974	0.1506	0.1726	0.2119	0.1830	0.2216	0.1365	0.1664	0.2753	0.1408	0.1862	0.1804	0.0274	0.2079	0.2456	0.1389	0.2753	0.0274	0.1733
Products of forestry, logging and related services	0.1263	0.1852	NA	0.1398	0.1555	0.1999	0.0275	0.1526	0.1625	0.0272	0.3781	0.2758	0.1323	0.1155	0.0308	0.1163	0.0031	0.1653	0.3781	0.0031	0.1408
Rubber and plastic products	0.1500	0.1227	0.0406	0.0978	0.1570	0.1520	0.0810	0.2830	0.0613	0.2463	0.0936	0.1362	0.1708	0.1441	0.1151	0.0666	0.0850	0.1389	0.2830	0.0406	0.1301
Textiles, wearing apparel, leather and related products	0.3093	0.2426	0.2879	0.2299	0.3738	0.3123	0.3529	0.2691	0.2140	0.3250	0.2188	0.2952	0.3436	0.2074	0.2254	0.2240	0.3628	0.4613	0.4613	0.2074	0.2920
Wood and of products of wood and cork	0.1134	0.1437	0.0555	0.0984	0.1337	0.1725	0.1481	0.2815	0.1491	0.1129	0.1887	0.1211	0.2357	0.0879	0.1755	0.0697	0.0678	0.0447	0.2815	0.0447	0.1333
Total	0.1464	0.1356	0.0943	0.1362	0.1266	0.1883	0.1306	0.2337	0.0991	0.1360	0.1500	0.1752	0.1406	0.1596	0.1379	0.1298	0.1212	0.2118	0.2337	0.0943	0.1474

Source: Own Calculations. Data from the Supply Table at current price under the National Account in the EUROSTAT database. Industries are categorized under the statistical classification of products by activity (CPA).

Table D: International Correlation of Consumptions

Countries	Australia	Austria	Belgium	Canada	Denmark	Euro Area	Finland	France	Germany	Hungary	Italy	Japan	Luxembou	Mexico	Netherlan	New Zeala	Norway	Poland	Portugal	Sweden	Switzerlar	UK	US
Australia	1.00	0.16	0.16	0.57	0.59	0.48	0.62	0.38	0.14	0.46	0.37	0.20	0.24	0.59	0.31	0.53	0.53	0.08	0.28	0.61	0.22	0.63	0.72
Austria	0.16	1.00	0.43	0.13	0.13	0.65	0.22	0.60	0.45	-0.04	0.69	0.06	0.25	0.31	0.27	-0.01	0.15	-0.06	0.44	0.48	0.27	0.00	0.47
Belgium	0.16	0.43	1.00	0.36	0.13	0.65	0.21	0.50	0.25	-0.30	0.70	-0.04	0.21	0.20	0.59	-0.22	0.19	0.30	0.78	0.43	0.34	0.00	0.12
Canada	0.57	0.13	0.36	1.00	0.53	0.57	0.57	0.32	0.16	0.27	0.50	0.23	0.38	0.66	0.37	0.27	0.62	0.23	0.43	0.66	0.19	0.65	0.51
Denmark	0.59	0.13	0.13	0.53	1.00	0.32	0.64	0.13	-0.03	0.14	0.29	0.37	0.24	0.65	0.07	0.60	0.68	0.19	0.16	0.46	0.06	0.55	0.57
Euro Area	0.48	0.65	0.65	0.57	0.32	1.00	0.47	0.85	0.65	0.17	0.78	0.04	0.45	0.54	0.69	0.00	0.43	0.13	0.73	0.73	0.48	0.36	0.61
Finland	0.62	0.22	0.21	0.57	0.64	0.47	1.00	0.27	0.13	0.36	0.46	0.37	0.17	0.60	0.17	0.56	0.57	0.25	0.25	0.47	-0.06	0.58	0.57
France	0.38	0.60	0.50	0.32	0.13	0.85	0.27	1.00	0.54	0.25	0.54	0.04	0.47	0.32	0.53	-0.03	0.29	-0.11	0.59	0.67	0.50	0.29	0.52
Germany	0.14	0.45	0.25	0.16	-0.03	0.65	0.13	0.54	1.00	0.12	0.31	0.06	0.25	0.32	0.38	-0.17	0.14	-0.05	0.20	0.46	0.37	0.17	0.43
Hungary	0.46	-0.04	-0.30	0.27	0.14	0.17	0.36	0.25	0.12	1.00	-0.02	0.10	0.07	0.29	-0.01	0.35	0.05	-0.34	-0.13	0.30	-0.04	0.46	0.42
Italy	0.37	0.69	0.70	0.50	0.29	0.78	0.46	0.54	0.31	-0.02	1.00	-0.08	0.24	0.39	0.48	-0.02	0.24	0.23	0.71	0.54	0.21	0.10	0.40
Japan	0.20	0.06	-0.04	0.23	0.37	0.04	0.37	0.04	0.06	0.10	-0.08	1.00	0.14	0.34	-0.20	0.52	0.43	-0.01	-0.10	0.27	-0.05	0.53	0.34
Luxembourg	0.24	0.25	0.21	0.38	0.24	0.45	0.17	0.47	0.25	0.07	0.24	0.14	1.00	0.41	0.35	-0.08	0.31	-0.02	0.26	0.38	0.30	0.33	0.39
Mexico	0.59	0.31	0.20	0.66	0.65	0.54	0.60	0.32	0.32	0.29	0.39	0.34	0.41	1.00	0.30	0.46	0.65	-0.03	0.28	0.63	0.31	0.72	0.82
Netherlands	0.31	0.27	0.59	0.37	0.07	0.69	0.17	0.53	0.38	-0.01	0.48	-0.20	0.35	0.30	1.00	-0.26	0.18	0.26	0.71	0.41	0.47	0.17	0.29
New Zealand	0.53	-0.01	-0.22	0.27	0.60	0.00	0.56	-0.03	-0.17	0.35	-0.02	0.52	-0.08	0.46	-0.26	1.00	0.56	-0.08	-0.15	0.31	-0.14	0.61	0.51
Norway	0.53	0.15	0.19	0.62	0.68	0.43	0.57	0.29	0.14	0.05	0.24	0.43	0.31	0.65	0.18	0.56	1.00	0.24	0.22	0.58	0.21	0.66	0.59
Poland	0.08	-0.06	0.30	0.23	0.19	0.13	0.25	-0.11	-0.05	-0.34	0.23	-0.01	-0.02	-0.03	0.26	-0.08	0.24	1.00	0.28	-0.09	-0.14	-0.07	-0.13
Portugal	0.28	0.44	0.78	0.43	0.16	0.73	0.25	0.59	0.20	-0.13	0.71	-0.10	0.26	0.28	0.71	-0.15	0.22	0.28	1.00	0.43	0.31	0.06	0.22
Sweden	0.61	0.48	0.43	0.66	0.46	0.73	0.47	0.67	0.46	0.30	0.54	0.27	0.38	0.63	0.41	0.31	0.58	-0.09	0.43	1.00	0.43	0.63	0.72
Switzerland	0.22	0.27	0.34	0.19	0.06	0.48	-0.06	0.50	0.37	-0.04	0.21	-0.05	0.30	0.31	0.47	-0.14	0.21	-0.14	0.31	0.43	1.00	0.22	0.42
UK	0.63	0.00	0.00	0.65	0.55	0.36	0.58	0.29	0.17	0.46	0.10	0.53	0.33	0.72	0.17	0.61	0.66	-0.07	0.06	0.63	0.22	1.00	0.71
US	0.72	0.47	0.12	0.51	0.57	0.61	0.57	0.52	0.43	0.42	0.40	0.34	0.39	0.82	0.29	0.51	0.59	-0.13	0.22	0.72	0.42	0.71	1.00
Avg.	**0.40**	**0.27**	**0.27**	**0.42**	**0.34**	**0.49**	**0.39**	**0.38**	**0.24**	**0.13**	**0.37**	**0.16**	**0.26**	**0.44**	**0.30**	**0.19**	**0.39**	**0.05**	**0.32**	**0.48**	**0.22**	**0.38**	**0.46**

Note: Statistics are calculated based on logged and HP-filtered quarterly seasonal adjusted private final consumption expenditure at constant prices from 1995:1-2013:2. Data source: OECD Main Economic Indicators.

Table E: International Correlation of GDP

Countries	Australia	Austria	Belgium	Canada	Denmark	Finland	France	Germany	Ireland	Italy	Japan	Luxembour	Mexico	Netherlands	New Zealan	Norway	Portugal	Spain	Sweden	Switzerland	UK	US	OECD - Total
Australia	1.00	0.43	0.36	0.35	0.37	0.48	0.37	0.32	0.38	0.22	0.30	0.45	0.42	0.34	0.36	0.47	0.21	0.40	0.40	0.36	0.54	0.53	0.47
Austria	0.43	1.00	0.89	0.81	0.83	0.89	0.94	0.89	0.83	0.87	0.52	0.84	0.75	0.88	0.17	0.45	0.64	0.92	0.86	0.89	0.81	0.75	0.87
Belgium	0.36	0.89	1.00	0.83	0.79	0.86	0.89	0.85	0.76	0.87	0.60	0.80	0.77	0.85	0.21	0.43	0.66	0.82	0.83	0.84	0.77	0.75	0.89
Canada	0.35	0.81	0.83	1.00	0.76	0.79	0.87	0.75	0.74	0.74	0.49	0.74	0.75	0.70	0.25	0.35	0.48	0.76	0.84	0.73	0.74	0.82	0.85
Denmark	0.37	0.83	0.79	0.76	1.00	0.83	0.81	0.81	0.80	0.80	0.64	0.70	0.81	0.76	0.27	0.53	0.54	0.79	0.81	0.76	0.82	0.79	0.89
Finland	0.48	0.89	0.86	0.79	0.83	1.00	0.87	0.88	0.75	0.87	0.66	0.77	0.81	0.81	0.21	0.50	0.62	0.85	0.86	0.81	0.87	0.76	0.90
France	0.37	0.94	0.89	0.87	0.81	0.87	1.00	0.89	0.81	0.89	0.52	0.85	0.72	0.83	0.19	0.40	0.64	0.89	0.89	0.88	0.80	0.78	0.88
Germany	0.32	0.89	0.85	0.75	0.81	0.88	0.89	1.00	0.75	0.92	0.63	0.75	0.70	0.85	0.18	0.42	0.64	0.84	0.83	0.84	0.78	0.63	0.85
Ireland	0.38	0.83	0.76	0.74	0.80	0.75	0.81	0.75	1.00	0.73	0.51	0.74	0.69	0.72	0.30	0.53	0.42	0.80	0.72	0.75	0.76	0.72	0.81
Italy	0.22	0.87	0.87	0.74	0.80	0.87	0.89	0.92	0.73	1.00	0.65	0.76	0.70	0.79	0.14	0.42	0.65	0.82	0.86	0.84	0.78	0.62	0.84
Japan	0.30	0.52	0.60	0.49	0.64	0.66	0.52	0.63	0.51	0.65	1.00	0.48	0.63	0.40	0.49	0.49	0.25	0.44	0.64	0.46	0.78	0.65	0.79
Luxembourg	0.45	0.84	0.80	0.74	0.70	0.77	0.85	0.75	0.74	0.76	0.48	1.00	0.60	0.72	0.25	0.33	0.61	0.79	0.77	0.78	0.71	0.69	0.78
Mexico	0.42	0.75	0.77	0.75	0.81	0.81	0.72	0.70	0.69	0.70	0.63	0.60	1.00	0.68	0.22	0.61	0.44	0.65	0.75	0.68	0.78	0.83	0.87
Netherlands	0.34	0.88	0.85	0.70	0.76	0.81	0.83	0.85	0.72	0.79	0.40	0.72	0.68	1.00	0.02	0.41	0.78	0.89	0.70	0.88	0.65	0.58	0.74
New Zealand	0.36	0.17	0.21	0.25	0.27	0.21	0.19	0.18	0.30	0.14	0.49	0.25	0.22	0.02	1.00	0.41	-0.18	0.16	0.27	0.01	0.47	0.41	0.40
Norway	0.47	0.45	0.43	0.35	0.53	0.50	0.40	0.42	0.53	0.42	0.49	0.33	0.61	0.41	0.41	1.00	0.16	0.41	0.38	0.42	0.58	0.53	0.57
Portugal	0.21	0.64	0.66	0.48	0.54	0.62	0.64	0.64	0.42	0.65	0.25	0.61	0.44	0.78	-0.18	0.16	1.00	0.62	0.56	0.71	0.37	0.34	0.49
Spain	0.40	0.92	0.82	0.76	0.79	0.85	0.89	0.84	0.80	0.82	0.44	0.79	0.65	0.89	0.16	0.41	0.62	1.00	0.76	0.87	0.78	0.65	0.79
Sweden	0.40	0.86	0.83	0.84	0.81	0.86	0.89	0.83	0.72	0.86	0.64	0.77	0.75	0.70	0.27	0.38	0.56	0.76	1.00	0.74	0.84	0.81	0.90
Switzerland	0.36	0.89	0.84	0.73	0.76	0.81	0.88	0.84	0.75	0.84	0.46	0.78	0.68	0.88	0.01	0.42	0.71	0.87	0.74	1.00	0.71	0.64	0.78
UK	0.54	0.81	0.77	0.74	0.82	0.87	0.80	0.78	0.76	0.78	0.78	0.71	0.78	0.65	0.47	0.58	0.37	0.78	0.84	0.71	1.00	0.84	0.93
US	0.53	0.75	0.75	0.82	0.79	0.76	0.78	0.63	0.72	0.62	0.65	0.69	0.83	0.58	0.41	0.53	0.34	0.65	0.81	0.64	0.84	1.00	0.92
OECD - Total	0.47	0.87	0.89	0.85	0.89	0.90	0.88	0.85	0.81	0.84	0.79	0.78	0.87	0.74	0.40	0.57	0.49	0.79	0.90	0.78	0.93	0.92	1.00
Avg.	**0.39**	**0.76**	**0.74**	**0.69**	**0.72**	**0.76**	**0.75**	**0.73**	**0.68**	**0.72**	**0.55**	**0.68**	**0.68**	**0.68**	**0.24**	**0.45**	**0.48**	**0.71**	**0.73**	**0.70**	**0.73**	**0.68**	**0.78**

Note: Statistics are calculated based on logged and HP-filtered quarterly seasonal adjusted gross domestic product at constant prices from 1963:3-2013:2. Data source: OECD Main Economic Indicators.

Table F: Cross Correlation Between GDP and Consumption

Countries	**(-4)**	**(-3)**	**(-2)**	**(-1)**	**0**	**(+1)**	**(+2)**	**(+3)**	**(+4)**
Australia	0.05	0.26	0.47	0.60	0.68	0.61	0.43	0.23	0.11
Austria	-0.27	-0.12	0.05	0.23	0.40	0.53	0.61	0.63	0.62
Belgium	-0.15	-0.05	0.14	0.36	0.50	0.46	0.30	0.12	0.00
Canada	0.02	0.15	0.35	0.52	0.62	0.61	0.45	0.17	-0.15
Denmark	0.11	0.25	0.36	0.48	0.68	0.67	0.58	0.51	0.30
Finland	-0.03	0.17	0.40	0.61	0.75	0.74	0.66	0.42	0.17
France	0.17	0.29	0.45	0.58	0.66	0.61	0.53	0.40	0.23
Germany	0.12	0.30	0.44	0.46	0.52	0.46	0.41	0.34	0.25
Italy	-0.36	-0.12	0.16	0.43	0.61	0.66	0.63	0.50	0.32
Japan	-0.20	-0.08	0.10	0.42	0.77	0.70	0.53	0.42	0.22
Luxembourg	0.24	0.35	0.46	0.51	0.54	0.36	0.24	0.16	0.03
Mexico	0.29	0.46	0.66	0.82	0.91	0.74	0.53	0.31	0.13
Netherlands	0.41	0.53	0.65	0.72	0.71	0.59	0.42	0.24	0.06
New Zealand	0.19	0.33	0.50	0.58	0.66	0.60	0.42	0.28	0.11
Norway	0.08	0.23	0.39	0.55	0.65	0.53	0.49	0.34	0.25
Portugal	0.04	0.25	0.49	0.70	0.83	0.71	0.60	0.46	0.27
Sweden	0.04	0.27	0.48	0.62	0.79	0.77	0.61	0.41	0.10
Switzerland	0.26	0.31	0.40	0.49	0.59	0.59	0.50	0.39	0.24
UK	0.12	0.34	0.59	0.78	0.86	0.82	0.66	0.41	0.13
US	0.46	0.63	0.78	0.88	0.91	0.85	0.70	0.51	0.31
Avg.	**0.08**	**0.24**	**0.42**	**0.57**	**0.68**	**0.63**	**0.51**	**0.36**	**0.18**

Note: Statistics are calculated based on logged and HP-filtered quarterly seasonal adjusted private final consumption expenditure at constant prices and gross domestic products at constant prices from periods 1995:1-2013:2. Data source: OECD Main Economic Indicators.

Table G: Autocorrelations of RER

Countries	(-1)	(-2)	(-3)	(-4)
Australia	0.79	0.55	0.37	0.20
Belgium	0.84	0.59	0.36	0.18
Canada	0.83	0.58	0.39	0.22
Denmark	0.79	0.50	0.25	0.03
Finland	0.88	0.69	0.51	0.31
France	0.80	0.55	0.36	0.19
Germany	0.83	0.58	0.32	0.07
Greece	0.68	0.46	0.32	0.23
Iceland	0.79	0.61	0.37	0.11
Ireland	0.79	0.48	0.24	0.06
Italy	0.84	0.60	0.38	0.17
Japan	0.83	0.59	0.45	0.28
Luxembourg	0.80	0.54	0.32	0.13
Mexico	0.80	0.56	0.33	0.05
Netherlands	0.83	0.58	0.32	0.08
New Zealan	0.84	0.64	0.45	0.29
Norway	0.71	0.35	0.05	-0.18
Portugal	0.78	0.51	0.28	0.04
Spain	0.83	0.60	0.38	0.18
Sweden	0.81	0.55	0.33	0.13
Switzerland	0.80	0.54	0.31	0.07
UK	0.80	0.52	0.32	0.16
US	0.81	0.55	0.36	0.19
Avg.	**0.80**	**0.55**	**0.34**	**0.14**

Note: Statistics are calculated based on logged and HP-filtered quarterly seasonal adjusted real effective exchange rate from 1980:1-2013:2. Data source: International Financial Statistics

Table H: Autocorrelations of RGDP

Countries	(-1)	(-2)	(-3)	(-4)
Australia	0.69	0.49	0.29	0.07
Austria	0.75	0.56	0.37	0.16
Belgium	0.84	0.56	0.25	0.01
Canada	0.85	0.63	0.42	0.21
Denmark	0.75	0.55	0.36	0.14
Finland	0.82	0.69	0.53	0.33
France	0.57	0.50	0.38	0.17
Germany	0.81	0.62	0.42	0.23
Ireland	0.83	0.70	0.49	0.29
Italy	0.82	0.56	0.27	0.00
Japan	0.79	0.57	0.35	0.11
Luxembourg	0.83	0.64	0.38	0.16
Mexico	0.87	0.67	0.43	0.24
Netherlands	0.62	0.48	0.34	0.16
New Zealan	0.75	0.54	0.42	0.21
Norway	0.67	0.52	0.35	0.23
Portugal	0.86	0.70	0.50	0.28
Spain	0.81	0.67	0.48	0.25
Sweden	0.71	0.54	0.35	0.20
Switzerland	0.84	0.66	0.50	0.28
UK	0.82	0.66	0.47	0.25
US	0.88	0.70	0.49	0.28
OECD - Tota	0.89	0.70	0.46	0.22
Avg.	**0.78**	**0.60**	**0.40**	**0.19**

Note: Statistics are calculated based on logged and HP-filtered quarterly seasonal adjusted GDP at constant prices from 1980:1-2013:2. Data source: OECD Main Economic Indicators.