

# Economic Development, Exchange Rates, and the Structure of Trade

Very preliminary and incomplete!

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## **Abstract**

The paper examines the effects of a changing trade and consumption structure on emerging economies. If differentiated products become more important as countries develop, this has implications for the optimal exchange rate regime as a function of economic development. This is distinct from the well-known Balassa-Samuelson effect, which predicts a real exchange rate appreciation as countries grow. Here the emphasis is on the responsiveness of domestic prices to exchange rate changes, or the extent of exchange rate pass-through. Empirical evidence supports the assumption that poor countries face a much higher pass-through, which can be explained by the importance of differentiated products in their trade structure and by differences in pricing behavior.

## **1 Introduction**

The extent of exchange rate pass-through is an important question both for economic research and for policymakers. For the latter, the size of short- and long-run pass-through is a key input into monetary policy decisions. For academic economists, many puzzling facts have emerged that challenge researchers to try and explain them.

This paper tackles one stylized fact related to exchange rate pass-through: that it seems to be systematically related to the level of economic development. In particular, various articles document that pass-through is faster in less-developed countries.<sup>1</sup>

There are many explanations for why pass-through is incomplete and gradual, and there are some attempts to answer its relationship to economic development. The explanation to the first phenomenon usually relies on two assumptions: international price discrimination and staggered price and/or wage setting. The second stylized fact has been explained by the differences in the monetary environment between developed and developing economies. While these explanations have merit, in this paper present an alternative setup that incorporates both facts in a consistent way, without resorting to ad-hoc assumptions about price setting behavior.

The arguments advanced in earlier work rely on features of the macroeconomic environment that may be different between developed and developing economies. Campa and Goldberg (2005), however, provide evidence that macroeconomic differences explain little of the variability of pass-through. Instead they find that most of the heterogeneity is accounted for by differences in industrial structure. In addition, Campa and Goldberg (2005) find that the two commonly used pricing assumptions, “local currency pricing” (LCP) and “producer currency pricing” (PCP) are both rejected by their data. These observations lead one towards a different modelling environment to explain incomplete exchange rate pass-through.

This paper builds a model which can explain a following facts, discussed above:

- Domestic prices respond to changes to in the nominal exchange rate only gradually.
- Pass-through is faster in developing countries.
- The main variable which determines aggregate pass-through is the structural composition of foreign trade.

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<sup>1</sup> See, for example, Calvo and Reinhart (2002) Choudhri and Hakura (2001) Devereux et al. (2005)

The framework I use is a two-sector, small open economy model with money in the utility providing a nominal side. The model relies on a modified version of the Helpman-Krugman (Helpman and Krugman 1985, Chapter 6-8) model of international trade, which combines insights from models based on comparative advantage with those from models based on increasing returns to scale.

The key mechanism is the following. As countries develop, they switch production from homogeneous products produced by competitive firms towards differentiated goods produced by companies with market power. Since in the former sector firms are price takers, pass-through is expected to be fast and complete. In the latter case, however, as firms make profits and are price setters, they can accommodate some of the exchange rate change in the short run. Thus for differentiated products pass-through should be incomplete and gradual.

Since the structure of production is systematically related to the level of development, and this structure has implications for pricing, exchange rate pass-through is linked to the level of development through this mechanism. Consistent with the Helpman-Krugman model, as countries become richer, they not only produce more differentiated products, but a larger share of their total trade is composed of such goods, which leads to an overall lower pass-through, consistent with the available evidence.

The rest of the paper is structured as follows. Section 2 presents some evidence on the relation between trade patterns and the level of development. Section 3 describes the theoretical model, while Section 4 presents the equilibrium conditions. Section 5 shows the main results through simulations. Finally, Section 6 concludes.

## **2 Some evidence**

An important element of the argument presented in the Introduction is that the structure of trade is systematically different between rich and poor countries. In this section I present some evidence that supports this assumption.

The important question concerns the relationship between the level of

	Imports	Exports
Poor countries	3.12	2.15
Rich countries	6.67	17.56

Tab. 1: Importance of differentiated products in trade (country averages)

development and the nature of the product composition of trade. To measure this, one needs data on the extent of product differentiation among traded products. The dataset I use is described in Rauch (1999). Rauch organizes trade goods into three categories: (1) products that are traded at organized exchanges, (1) products that have a reference price, and (3) products that do not have a reference price.

I merge the Rauch categorization with export-import data from the World Bank database on international trade and GDP data from the Penn World Tables. The dataset contains 110 countries between 1980-1988.

The hypothesis I test is that a more developed country's trade pattern is tilted towards category (3). The main variables I use to measure specialization is the ratio of category (3) imports (exports) to category (1) imports (exports). Given the panel nature of the data, I estimate a fixed effects specification where the explanatory variables include per capita GDP, population and general openness as measured by the share of exports plus imports in GDP.

Table 1 presents mean values for the relative import and export measures for two country groups: poor nations with a per capita GDP below \$5,000, and rich nations with a per capita GDP above \$15,000. The table clearly shows that in both imports and exports rich countries have a much larger category (3) share. While already large for imports, the differences are very dramatic for exports.

Table 2 shows the estimation results for imports and exports. The same pattern emerges as in Table 1. GDP has a large and significant impact on the share of category (3) imports and exports relative to category (1) imports and exports. Thus I take that the evidence strongly supports this key assumption of the model.

	Imports	Exports
Log(GDP)	5.03 (0.595)**	8.32 (1.786)**
Log(Population)	6.05 (1.538)**	-10.46 (4.612)*
Openness	0.01 -0.01	-0.01 -0.03
Constant	-92.17 (12.281)**	33.38 -36.83
Observations	985	985
Number of ccode	110	110
R-squared	0.16	0.03

Standard errors in parentheses

\* significant at 5%; \*\* significant at 1%

Tab. 2: Trade patterns and development

### 3 The model

I focus on a small open economy (Home) that produces two goods, food and manufactures. Food is homogeneous, and it is produced by competitive firms who use only land, which is available in a fixed amount to household.

Manufactures require labor (human capital), supplied by household through their labor/leisure decisions. There are a continuum of varieties in the manufacturing sector, which are completely symmetric, but imperfect substitutes in consumption.

The key assumption of the model is that manufacturing is oligopolistic, with two firms (a domestic and a foreign) competing in a Cournot fashion in the market of each variety. Thus companies choose output, given their competitor's decision and the inverse demand curve for their product.

Manufacturing firms produce both for the domestic and foreign markets, which are segmented so that there may be different prices offered on the two markets. One reason for the lack of arbitrage is that exporting is subject to a transportation cost. Food, on the other hand, is costlessly tradable, so there is a full and immediate pass-through of the exchange rate into food prices.

### 3.1 Households

Households solve the following problem:

$$\begin{aligned} \max \quad U &= \sum_{t=0}^{\infty} \frac{1}{(1+\rho)^t} \left[ \log C_t^\alpha (Y_t - \Gamma)^{1-\alpha} + \mu \log \frac{M_t}{P_t} - \chi \log(\bar{H} - H) \right] \\ \text{s.t.} \quad C_t &= \left[ \int_0^1 c_t(i)^{1-1/\sigma} di \right]^{\frac{\sigma}{\sigma-1}} \\ V_t L + W_t H + \Pi_t + M_t &= P_t C_t + E_t Y_t + M_{t+1} \end{aligned}$$

where  $C$  is a CES aggregate of differentiated products  $c(i)$  (manufacturing),  $Y$  is a homogeneous good (food),  $\Gamma$  is the subsistence level of food consumption,  $M$  is money demand by households,  $H$  is the labor supply,  $\bar{H}$  is the total time endowment,  $W$  is the nominal wage,  $V$  is the rental rate of land, and  $E$  is the nominal exchange rate. I assume that the Law of One Price holds for food, so that the price of food is also  $E$ . The manufacturing price index  $P$  takes the usual form,

$$P = \left[ \int_0^1 p(i)^{1-\sigma} di \right]^{\frac{1}{1-\sigma}}.$$

Let  $\lambda_t$  be the Lagrangian multiplier associated by the period budget constraint. The Lagrangian is written as

$$\begin{aligned} \mathcal{L} &= \sum_{t=0}^{\infty} \frac{1}{(1+\rho)^t} \left\{ C_t^\alpha (Y_t - \Gamma)^{1-\alpha} + \mu \log \frac{M_t}{P_t} + \chi \log(\bar{H} - H_t) \right. \\ &\quad \left. + \lambda_t [V_t L + W_t H_t + \Pi_t + M_t - P_t C_t - E_t Y_t - M_{t+1}] \right\}, \end{aligned}$$

with  $C$  given as above. The first-order conditions of the problem are

$$\frac{\alpha}{C_t} = \lambda_t p_t(i) \tag{1}$$

$$\frac{1-\alpha}{Y_t - \Gamma} = \lambda_t E_t \tag{2}$$

$$\frac{\mu}{M_{t+1}} = (1+\rho)\lambda_t - \lambda_{t+1} \tag{3}$$

$$\frac{\chi}{\bar{H} - H_t} = \lambda_t W_t \tag{4}$$

The allocation of manufacturing spending  $PC$  follows the well-known first-order condition,

$$c(i) = \left[ \frac{p(i)}{P} \right]^{-\sigma} C. \quad (5)$$

## 3.2 Producers

### 3.2.1 Food

Food is produced by constant returns-to-scale, perfectly competitive firms. The unit land requirement is normalized to 1 for simplicity, which guarantees that

$$V_t = E_t.$$

Land is supplied inelastically, so domestic production must equal the amount of available land,  $L$ .

### 3.2.2 Manufactures

The domestic market is oligopolistic, with the Home and Foreign firms competing in a Cournot fashion. For simplicity, I assume that there is only 1 domestic and 1 foreign company producing a particular variety. Markets are internationally segmented, so domestic sales must be priced in domestic currency.

Home producers produce with a marginal cost of  $aW$ , where  $a \geq 1$  is the unit labor requirement parameter which reflects the level of development of the Home economy. For simplicity, I assume that  $a$  is given exogenously, and it is constant for the time horizon of the monetary model. The second assumption is conceptually straightforward, but computationally tedious, to relax, so I opt for the simpler case. The marginal cost of foreign companies is  $\tau EW^*$ , where  $\tau > 1$  represents transportation costs.

Equation (5) can be rearranged to get the inverse demand function for an individual variety,

$$p(i) = PC^{1/\sigma} c(i)^{-1/\sigma} = kc(i)^{-1/\sigma},$$

where  $k$  represents variables that cannot be influenced by individual firms. Let us ignore the index  $i$  for product varieties and let  $x$  and  $x^f$  indicate production by the Home and Foreign firm, respectively. Home market profits for Home and Foreign companies can then be written as

$$\begin{aligned}\pi &= \left[ k(x + x^f)^{-1/\sigma} - aW \right] x \\ \pi^f &= \left[ k(x + x^f)^{-1/\sigma} - EW^*\tau \right] x^f.\end{aligned}$$

After maximizing profits, finding the Nash equilibrium, and using the definition of  $k$ , we arrive at the following:

$$p = \frac{aW + EW^*\tau}{2 - 1/\sigma} \quad (6)$$

$$x = \frac{\alpha\sigma(p - aW)}{\lambda p^2} \quad (7)$$

$$\pi = \frac{\alpha\sigma(p - aW)^2}{\lambda p^2} \quad (8)$$

### 3.2.3 Exports

I assume that Home is a “quasi-small” open economy. Firms compete on the foreign market the same way they do at home, but the economy-wide foreign variables  $W^*$  and  $\lambda^*$  are not affected by Home conditions. In particular, I set these values at their steady state levels with  $a = 1$ .<sup>2</sup>

The functional forms for the export price  $p^*$ , export quantity  $z$  and profits from exports  $\pi^*$  are analogous to the domestic ones, i.e.

$$p^* = \frac{\tau aW + W^*}{E(2 - 1/\sigma)} \quad (9)$$

$$z = \frac{\alpha\sigma(p^* - \tau aW)}{\lambda^* (p^*)^2} \quad (10)$$

$$\pi^* = \frac{\alpha\sigma(p^* - a\tau W)^2}{\lambda^* (p^*)^2}. \quad (11)$$

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<sup>2</sup> Analytical solutions for  $W^*$  and  $\lambda^*$  are easy to derive, but not very illuminating. They are available from the author upon request.

Notice that the nominal foreign variables are measured in foreign currency.

## 4 Equilibrium

The equilibrium of the model can be described by (1) international market clearing for goods, (2) domestic market clearing for factors, and (3) the evolution of the dynamic variables. This section presents the main equations.

### 4.1 The labor market

Labor supply is given by 4, and labor demand follows from manufacturing firms' decisions:

$$H = ax + a\tau z. \quad (12)$$

These two equations can be solved for the wage rate,  $W$  and for the level of manufacturing employment,  $H$  as a function of the marginal utility of income,  $\lambda$ .

### 4.2 Dynamics and the steady state

The dynamic system that determines the evolution of the remaining endogenous variables consists of two equations with two variables:  $M$  and  $\lambda$ . All other variables have been expressed as functions of these two through (6), (7), (8), (9), (10), (11), (4) and (12). The two dynamic equations then follow from (1), (2) and (3):

$$M_{t+1} = M_t + E_t L + W_t H_t + \pi_t + \pi_t^* - \frac{1}{\lambda} - E_t \Gamma \quad (13)$$

$$\lambda_{t+1} = (1 + \rho)\lambda_t - \frac{\mu}{M_{t+1}}. \quad (14)$$

The steady state can be calculated from (13) and (14) and the previous equations. While the general solution is a complicated function of parameters, the money demand function is easily expressed as

$$\bar{M} = \frac{\mu}{\rho\lambda}.$$

### 4.3 Log-linearization

The two-dimensional system described by (13) and (14) does not yield an analytical solution, but it is easy to solve the log-linearized version.<sup>3</sup> The system is saddle-path stable, and hence converges to the unique steady state.

The choice of some of the parameters is not obvious, since the model is non-standard. While I believe the values are meaningful, the results should be viewed as illustration for the qualitative conclusions, rather than quantitative predictions.

That said, I use the following values:

- $L = 1$ : a normalization of the land endowment
- $\sigma = 4$ : a value that is common in the literature for the extent of market power
- $\alpha = 0.7$ : the share of manufactures in consumption
- $\rho = 0.1$ : the steady state interest rate
- $\mu = 0.2$ : this implies that households' money holding equals two periods' consumption
- $\bar{H} = 2$ : the time endowment (a normalization)
- $\chi = 1$ : this choice implies a steady state level of labor supply of 0.71
- $\Gamma = 0.5$ : the subsistence level of food consumption equals half the domestic production
- $\tau = 1.2$ : moderate levels of trade costs that are consistent with positive exports

The log-linearization procedure is standard, but the resulting equations are not very illuminating. The details for the interested reader can be found in the Appendix.

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<sup>3</sup> The procedure and the resulting equations are available in a Maple worksheet from the author upon request.

## 5 Results

I use the following policy experiment to describe the model's predictions. I assume that Home is initially in steady state with a fixed exchange rate equal to unity ( $E = 1$ ). Then the exchange rate is devalued unexpectedly by 10%, and remains at the new level forever ( $E' = 1.1$ ). I examine the response of the endogenous variables to the exchange shock. I contrast the results for two levels of development: when Home is similar to Foreign ( $a = 1$ ) and when Home is less productive ( $a = 2$ ).

Figures 1 and 2 show the main results. Figure 1 depicts the case of a developed country. As the figure shows, all variables respond to the shock in the expected way. In particular, the wage rate responds less than proportionately, and this means that prices also rise by less than 10%. The wage response means that Home firms enjoy an initial competitive advantage over their Foreign competitors, and both their domestic sales and their exports expand. Consistent with increased production, employment rises.

Admittedly some of the responses are quite moderate. Given that all nominal variables (except the money stock) are completely flexible in the model, this should not be surprising. Interestingly, however, while the wage rate and prices feature a partial but large pass-through, these small nominal deviations have quite sizable real effects. Manufacturing employment temporarily increases by close to 2%, while exports initially rise by more than 10%.

This result is interesting because it highlights the role of small price movements in restoring equilibria. The result is also consistent with other models that use a similar framework with a role for money but without other nominal rigidities.<sup>4</sup> This does not mean that nominal rigidities are not important, it simply indicates that they may not be the source of fluctuations, rather act as an amplification mechanism for underlying shocks.

Figure 2 shows the same responses when Home is less developed, i.e. its manufacturing productivity is half of Foreign's ( $a = 1$ ). While the qualitative

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<sup>4</sup> See, for example, Benczur and Konya (2005) for related work on the real effects of nominal exchange rate shocks.

results are the same as for the previous case, quantitatively the effects are smaller. Most importantly, pass-through is faster - compared to the case of  $a = 1$ , the price level's initial deviation from its long-run value drops to -0.37% from -0.5%. Again, the values are small, but the relative decrease (which indicates an increase in pass-through) is substantial.

The effects on manufacturing, however, are not necessarily smaller. Exports, for example, increase by almost 50%, and manufacturing employment rises by 2.3%. The reason for the expansion of exports is that they start from a low base, and are very responsive to cost changes. Thus the small increase in competitiveness translates into a large growth of export activity.

To summarize, the model is able to match qualitatively all the predictions that are expected from an exchange rate devaluation, and it also exhibits the systematic differences between developed and developing countries that the literature has identified. The next task is to incorporate amplification mechanisms that make the predicted effects quantitatively larger, to better accord with existing evidence.

## 6 Conclusion

In this paper I developed a simple general equilibrium model of a small open economy with two sectors and oligopolistic conduct. The model matches some important stylized facts reported in the literature on exchange rate pass-through: that it is incomplete in the short-run and gradual, and that pass-through is significantly smaller in advanced economies. I also presented evidence on the key assumption of the model, which is that advanced countries trade more differentiated products, while developing countries specialize in homogeneous goods.

The challenge for future research is both to provide more detailed evidence on trade patterns, and to incorporate other real or nominal rigidities that increase the quantitative impact of exchange rate shocks. Given the simple structure of the current model, this should be a relatively simple task, which would go a long way towards making the model more realistic.

## A The log-linearized model

The static equations that determine  $p$ ,  $x$ ,  $p^*$ ,  $z$ ,  $h$  and  $w$  are (6), (7), (9), (10), (4) and (12). The log-linearized equations (omitting the time indexes) are written as

$$\begin{aligned}\hat{p} &= \frac{a\bar{W}\hat{W}}{a\bar{W} + EW^*\tau} \\ \hat{p}^* &= \frac{a\tau\bar{W}\hat{W}}{a\tau\bar{W} + EW^*} \\ \hat{x} &= \frac{\bar{p}\hat{p} - a\bar{W}\hat{W}}{\bar{p} - a\bar{W}} - \hat{\lambda} - 2\hat{p} \\ \hat{z} &= \frac{\bar{p}^*\hat{p}^* - a\tau\bar{W}\hat{W}}{\bar{p}^* - a\tau\bar{W}} - 2\hat{p}^* \\ \hat{h} &= a\bar{x}\hat{x} + a\tau\bar{z}\hat{z} \\ \frac{\hat{h}}{H - \bar{h}} &= \hat{\lambda} + \hat{W},\end{aligned}$$

where the  $\hat{\cdot}$  notation indicates the log deviation of a variable from its steady state value, and the overbar denotes steady state values.

Given these variables, the dynamic equations are (13) and (14). The log-linearization yields

$$\begin{aligned}\hat{M}_{t+1} &= \hat{M}_t + \frac{\bar{p}\bar{x}}{M}(\hat{p}_t + \hat{x}_t) + \frac{\bar{p}^*\bar{z}}{M}(\hat{p}_t^* + \hat{z}_t) + \frac{1}{\lambda M}\hat{\lambda}_t \\ \hat{\lambda}_{t+1} &= (1 + \rho)\hat{\lambda}_t + \rho\hat{M}_{t+1}.\end{aligned}$$

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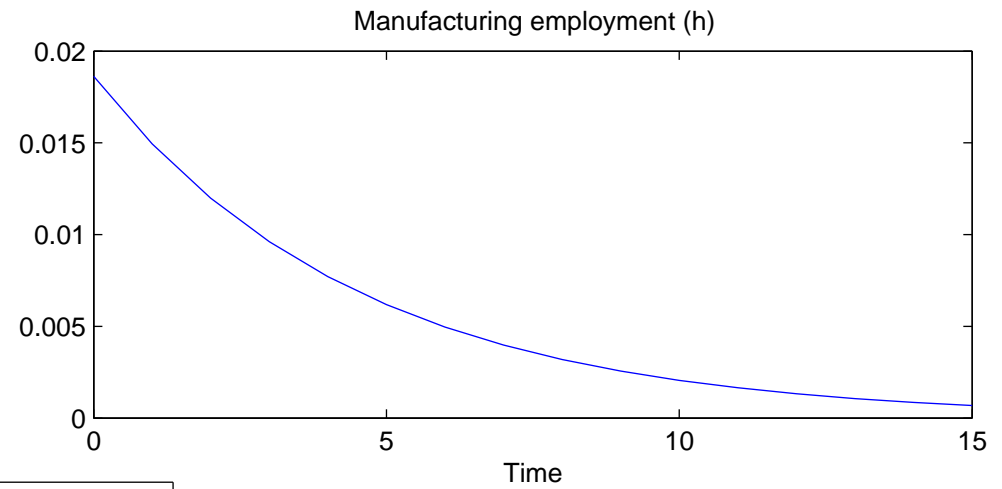
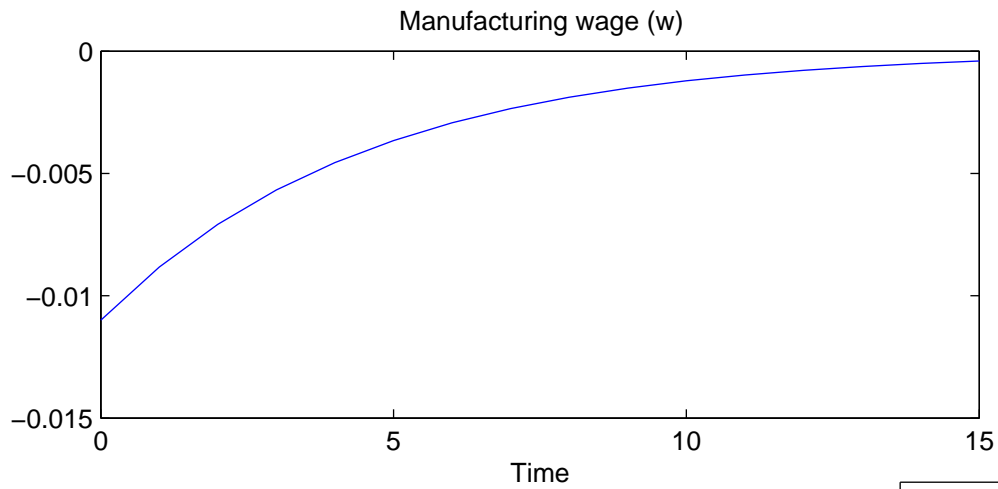
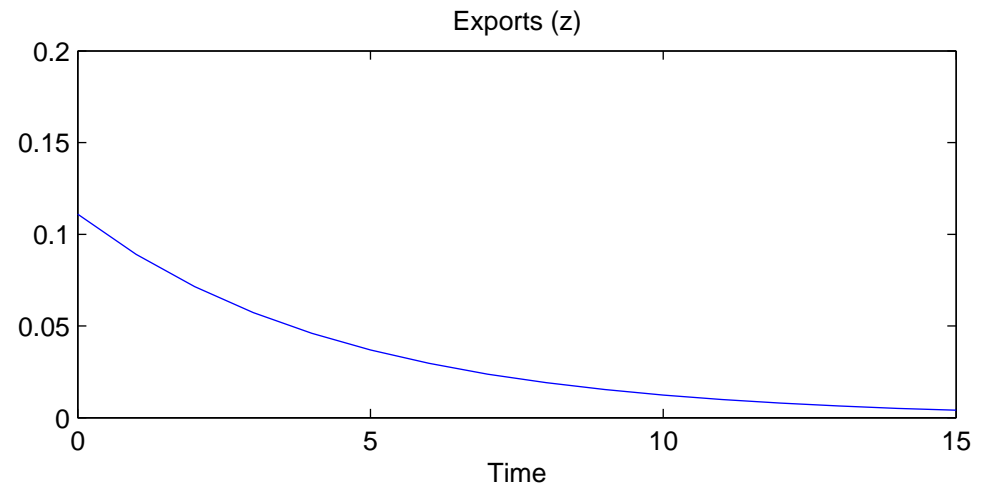
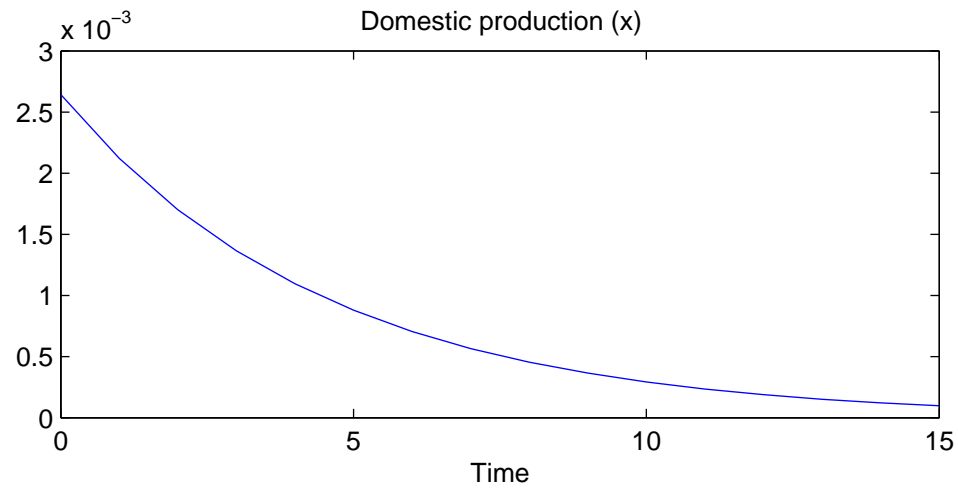
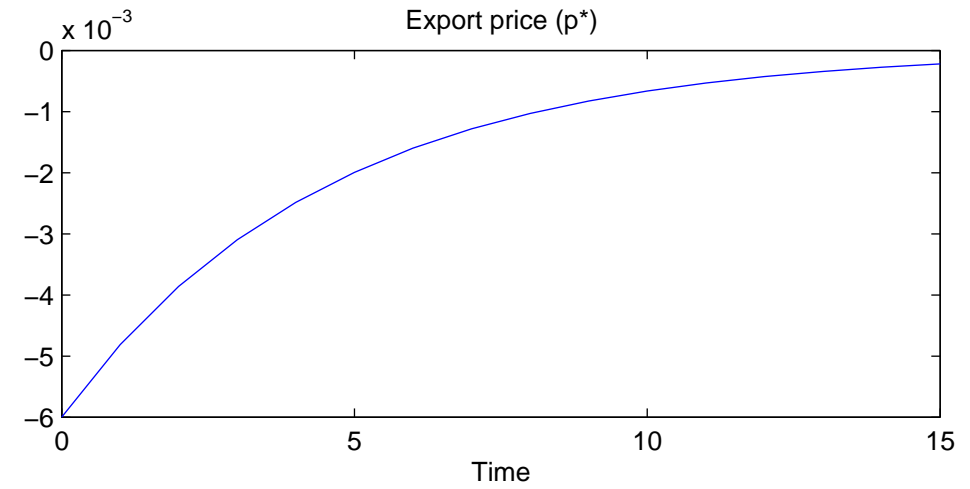
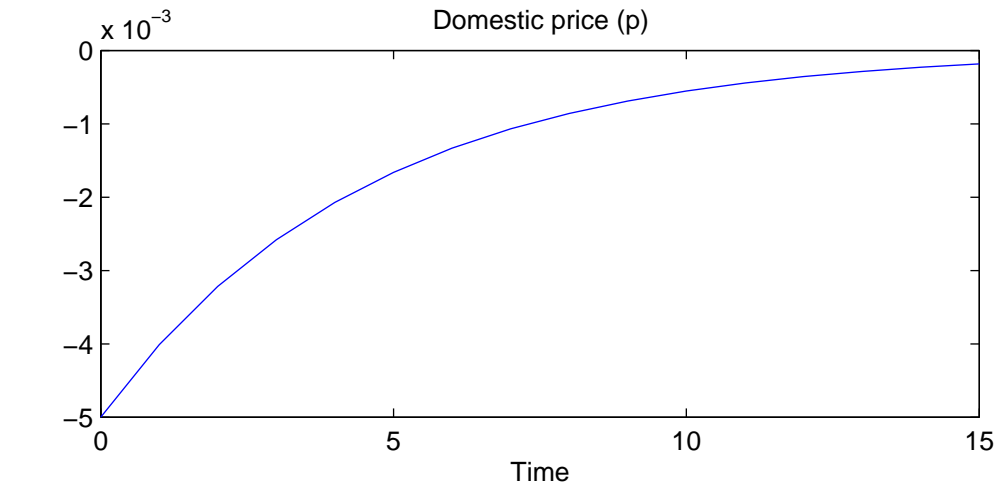


Figure 1: A 10% devaluation ( $a=1$ )

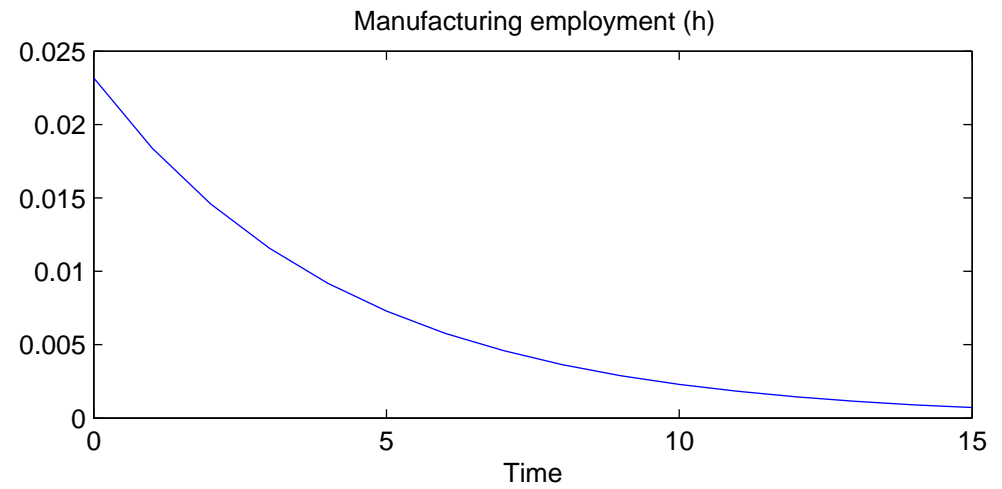
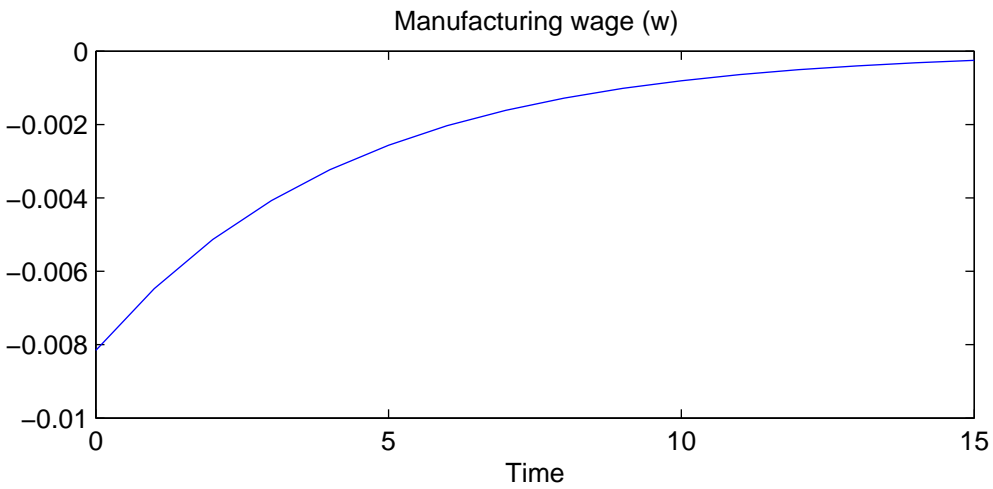
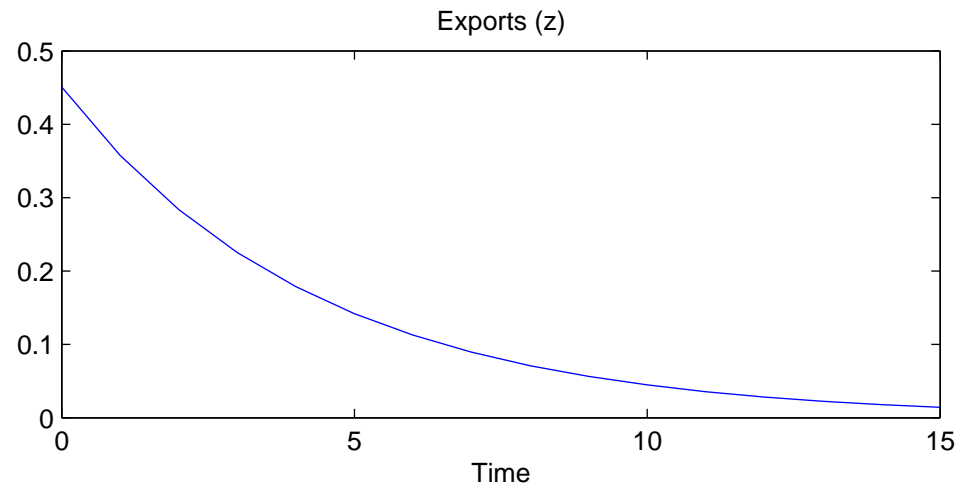
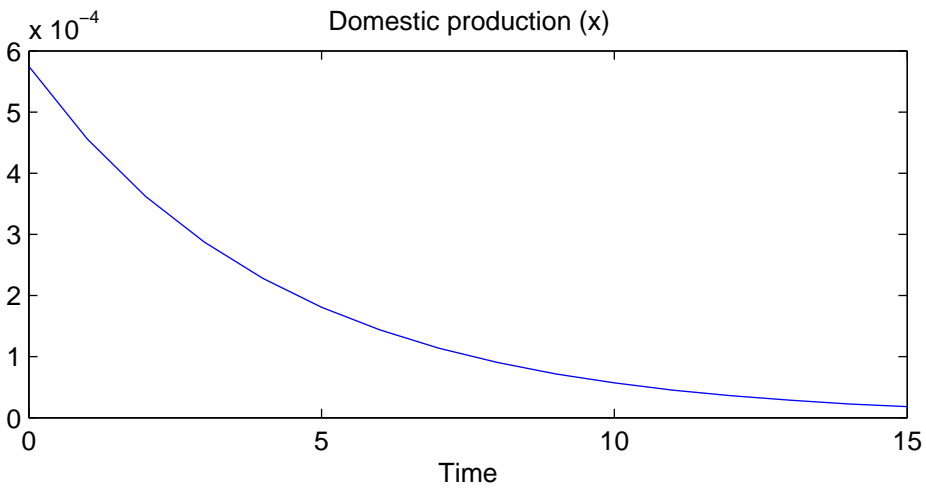
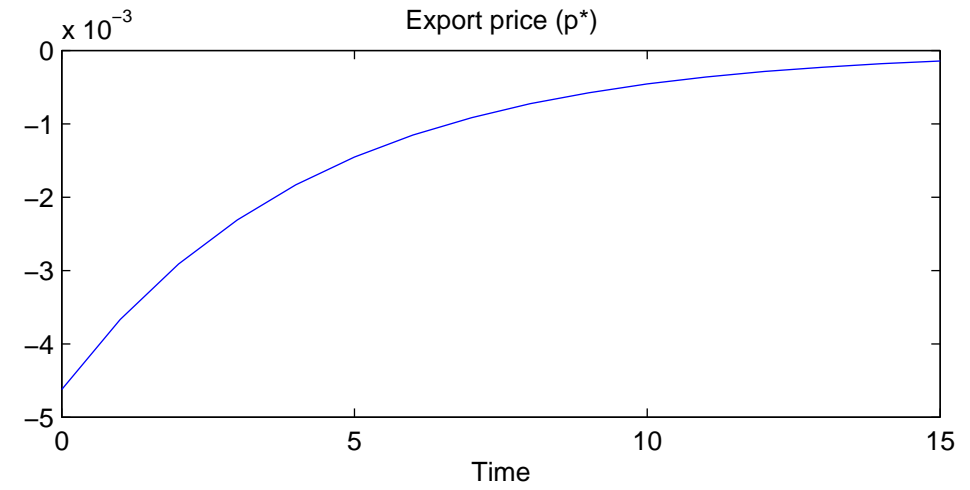
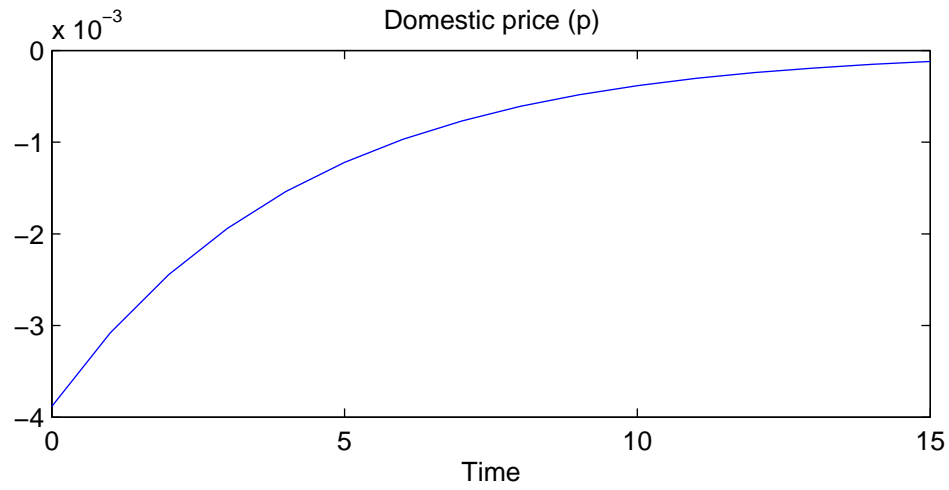


Figure 2: A 10% devaluation ( $a=2$ )