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ROLE OF STRUCTURAL CHANGES IN ASSESSING MONETARY AND EXCHANGE RATE POLICY OUTCOMES

The structural micro-model of the real sector based on Grossman's (2007) analysis can be used to find the conditions that result in structural changes due to the implementation of monetary and foreign exchange policies. Structural changes, such as in the set of goods that are produced and breaks in the GDP path, may possibly undermine the overall effect of the policy.

Numerical modeling is used to determine the sources of structural changes and to find the conditions under which there is a high possibility of negative structural changes, for instance a decreasing foreign exchange policy expansion exacerbated by a decreasing monetary policy contraction. Similar conditions may characterize the transition from exchange rate targeting to inflation targeting based on the interest rate. Other results are effects caused by structural changes: the possibility of a negative pass-through effect and uncertain diversification of the economy.

На основе разработанной структурной микромодели реального сектора в работе исследуются изменения структуры производства, вызванные проведением денежно-кредитной и валютной политики. Экономические последствия изменений производственной структуры могут в значительной мере повлиять на результаты монетарной политики и поэтому должны приниматься в расчет монетарными властями.

В результате численного моделирования было продемонстрировано, что при более мягкой денежно-кредитной и более жесткой валютной политике вероятность негативных структурных изменений возрастает. Подобное сочетание может характеризовать монетарную сферу страны при переходе от регулирования валютного курса к инфляционному таргетированию, основанному на управлении ставкой процента.

Используемый в работе структурный подход к анализу реального сектора экономики позволяет объяснить возможность возникновения отрицательного воздействия валютного курса на уровень цен, а также проанализировать диверсификацию производства в зависимости от денежно-кредитной и валютной политики.

1. Introduction

In this paper we assess the effects of monetary and foreign exchange policies on the real sector of the economy using a structural approach to the modeling of the real sector. The willingness to use an active foreign exchange policy as the main instrument for stimulating aggregate demand in many developing countries makes the analysis of its possible consequences for the real sector extremely important. Possible problems may arise when the monetary authorities change their operating procedures. In particular, the transition from regulating foreign exchange to managing the interest rate may create negative stimuli for the real sector even if the total level of monetary expansion remains the same. In order to analyze the structural changes in the real sector, it is necessary to augment the standard approach to modeling monetary policy by including a parameter that would characterize the production structure.

Since this topic is of great importance and constitutes a broad field of study, many real sector models have been suggested, which differ in their assumptions about the production function, the price mechanism, the market structure, etc. Below, we will mainly concentrate on the New-Keynesian framework and make a sufficiently broad set of assumptions about real sector behavior.

1.1. Output production

The most widespread approach consists in modeling output as a differentiated product with labor and capital as inputs (Krause, Lubik, 2007; Jeanne, 1998; Dennis, 2005; Christiano et al., 2005; Woodford, 1996). Another approach considers output to be a homogeneous product made out of intermediate goods produced from capital and labour (Clarida, Gali, Gertler, 2002; Gali, Monacelli, 1999; Clarida, Gali, Gertler, 1999). These frameworks dominate in the current literature on the analysis of monetary policy and are sufficient for most purposes. However, in order to consider the interaction between home and foreign producers (which is crucial for an active foreign exchange policy), it is necessary to introduce a slightly more complicated model. One such extension of these models consists in varying the structure of the real sector, and thus monitoring the appearance and disappearance of individual brands or even markets.

1.2. Demand and prices

The usual framework for the Keynesian type real sector models consists in various modifications of the standard Hicksian IS-LM model. In the simplest

versions of this model, prices are taken to be given, expenditure and money demand are sensitive to the interest rate, well-determined and have identifiable parameters, and output is perfectly elastic. Thus, monetary policy induces changes in aggregate demand and affects output, but has no effect on prices. Generally, prices are not assumed to be constant, but rather to adjust gradually, and output is assumed to depend on the productive potential of the economy. Prices are usually viewed as being determined by a simple mark-up on costs, and firms are involved in Calvo competition (Calvo, 1983). Therefore, aggregate demand pressure will have little or no direct impact on prices and will have more powerful effects on supply.

1.3. Tradable and non-tradable goods

The most common approach usually does not differentiate between tradable and non-tradable goods and is often designed to describe closed economies. An alternative framework (Svensson and van Wijnbergen (1989), Correia et al. (1995), Obstfeld and Rogoff (1996), McCallum and Nelson (1999), Dotsey and Duarte (2005)) allows for a detailed analysis of the real sector for an open economy. In spite of the significant advantages of models of this type, they still lack certain important features of the real sector while certain assumptions may be weakened (for instance, for the sake of solving a model, the tradable goods sector is usually assumed to consist of exporters only, who do not trade on the home market).

Therefore, in order to examine the effects of monetary and foreign exchange policies on the real sector in more detail, it was necessary to develop an alternative framework that would reveal many features of the real economy that are usually omitted. To do this, we had to reinforce the microeconomic component of the model, which would lead us to results for structural changes in the home economy.

In Section 2 we present the elaborated model. Sections 3 and 4 describe the results of numerical modeling and discuss the possible problems of implementing monetary and foreign exchange policies. Section 5 concludes.

2. The model

The microeconomic basis of the model is largely based on the work of Grossman (2007), in which he develops an asymmetric multiproduct oligopoly model with differentiated products. He presents a model where firms are endowed with possibly different marginal cost and product quality, and

choose product ranges before product market competition starts. Although the model was initially designed to prove a positive relationship between firm size and product diversification, it has all the properties needed for the evaluation of monetary policy effects, since unlike traditional frameworks it allows for structural changes in the market and also incorporates such important features as the possible asymmetry of the firms' characteristics. However, we introduced a multi-sector market structure in the model, as well as international trade, monetary and foreign exchange policy parameters, among other things, and this brought us to many interesting results.

2.1. Assumptions

Consider a world with two countries (called Home and Foreign), where each country's market is divided into spheres of tradable and non-tradable goods that are non-perfect substitutes for each other. Assume each country is represented by one producer[1] that supplies a variety of products to each market segment (the non-tradable segment and two tradable segments, for the Home and Foreign markets; international trade is present).

Denote:

NhH — the number of brands produced by the home firm for the tradable goods segment of the home economy;

NhF — the number of brands produced by the home firm for the tradable segment of the foreign economy;

NfF — the number of brands produced by the foreign firm for the tradable segment of the foreign economy;

NfH — the number of brands produced by the foreign firm for the tradable segment of the home economy;

NNH — the number of brands produced by the home firm for the non-tradable segment of the home economy;

NNF — the number of brands produced by the foreign firm for the non-tradable segment of the foreign economy.

All numbers of brands are assumed to be integer.

X-variables with the same identifications (i.e., Xhh, Xhf, XfH, Xff, XNH, XNF) stand for the volume of output of each type of brand (designed for the corresponding market segment by either the home or foreign firm)[2].

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[1] The assumption of there being only one producer in the economy is not crucial for the derived results; it could be relaxed without having any significant consequences, however, it greatly simplifies the analysis.

[2] It will be proved later that the optimal production of each brand are equal within the same firm's segment.

The inverse demand function has a linear form that can be written as

$$p_k = a_k - \lambda \cdot i - \beta \cdot x_k - \gamma \cdot \sum_{i \neq k} x_i - \eta \cdot \sum_j y_j \qquad (1)$$

Here p_k and x_k denote the price and quantity of product k, respectively; $\beta > \gamma > \eta > 0$; these coefficients may actually have different values in different countries (which allows for asymmetry in consumers' preferences over the set of goods belonging to different types). The group of products x_i denotes substitutes from the same segment (tradable or non-tradable goods) of the market, while the group y_j stands for products from the other segment[3]. The real interest rate is i, which has the traditional negative affect on demand.

Suppose $a_k = A_i$ and $c_k = C_i$ for each firm (thus, both product quality and unit cost apply to any brand a firm offers), which may hold if technology is of public nature (e.g., Caves, 1971). We also allow for differences in the quality parameters for different countries. Therefore, the following variables are introduced: AhH is the highest level of demand of home consumers for the output of the home firm; AfH is the highest level of demand of home consumers for the output of the foreign firm (import); AfF is the highest level of demand of foreign consumers for the output of their own firm; AhF is the highest level of demand of foreign consumers for their import (e.g., export goods from the point of view of the home market).

There are two stages during which firms make decisions non-cooperatively and simultaneously. During the first stage, the firm chooses its product range for each market segment it operates in. Let $C(N)$ denote the firm's costs associated with the necessity of introducing and maintaining N competitive brands[4]. These costs could cover marketing expenses on designing and advertising the brands.

The firm makes decisions about the output of each brand in the second stage, in accordance with the Cournot competition model with possible asymmetric costs and quality parameters.

All the nominal variables in the model are to be converted into one currency, the home one. Therefore, a foreign exchange policy may be viewed as one that changes foreign costs and the maximum demand for goods in the other country and measured in the home currency (for instance, the equivalent for foreign costs in the home currency is $c = c^* \cdot S \cdot (1 + e_{fe})$, where c^* is its value in terms of the foreign currency, S is the foreign exchange rate and e_{fe} reflects

the degree of foreign exchange expansion[5]. For the demand parameters, we may also write $AhF = AhF^* \cdot S \cdot (1 + e_{fe})$, $AfF = AfF^* \cdot S \cdot (1 + e_{fe})$).

Monetary policy is exercised as managing the interest rate, which is included in the model via its influence on part of the firm's fixed costs at home (associated with various issues sensitive to the interest rate such as interest on credits, rent, etc.) and also via its influence on demand (1). That is, the degree of monetary and foreign exchange expansion is measured as relative changes in the home interest rate and foreign exchange rate correspondingly.

2.2. Equilibrium analysis

First consider the profit maximization problem for the home competitor:

$$\max_{XhH_i, XhF_j, XhN_k, i \in NhH, j \in NhF, k \in NNh} \pi_h = \sum_{i \in NhH} (p_i - c_h) XhH_i + \sum_{j \in NhF} (p_j - c_h) XhF_j + \sum_{k \in NNh} (p_k - c_h) XhN_k \quad (2)$$

s.t. (1) and $a_i = AhH \quad \forall i \in [1, NhH], \quad a_j = AfH \quad \forall j \in [1, NhF], \quad a_k = AhH \quad \forall k \in [1, NNh]$

During the second stage the producer, given an established range of brands for each market segment, decides on the quantity of each type of good[6]. Note that fixed costs and expenditures on the creation and maintenance of the product range have not been considered yet, because they are irrelevant for making decisions at this stage. The foreign firm faces a profit-maximization problem similar to (2).

General principles of symmetry show that within each active market segment, the firm's output of each brand is equal. Quality-cost margins ($a_i - c_j$) have a positive effect on both output and profit. Generally, despite all our modifications to the structure of Grossman's original model, its overall properties remain the same[7].

The first stage in reaching equilibrium consists in the following profit-maximization problem (again in the notations for the home firm):

$$\max_{NhH, NhF, NNh} Pr_h (NhH, NhF, NNh, ...) = \pi_h (NhH, NhF, NNh, ...) - C(NhH, NhF, NNh) \qquad (3)$$

In other words, the firm now decides how many brands it should introduce to each of the market segment it is operating in. At this stage all costs are taken into consideration.

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[3] Suppose the product k refers to tradable goods, then the last part of the inverse demand function (1) is associated with non-tradable goods on the same national market.

[4] This function could be written in different forms depending on the market segment. However, we consider it to be twice continuously differentiable and concave.

[5] In terms of the relative change in the foreign exchange rate S.

[6] As postulated above, the demand functions are different in the corresponding market segments.

[7] For more details concerning the original model, see Grossman (2007).

Since it is not possible to formally examine the properties of the profit function, it is not possible to prove the existence of the equilibrium. However, provided that the function $C(\cdot)$ is concave and some of the endogenous variables are fixed, equilibrium conditions could be found.

A formal derivation of equilibrium conditions appears to be of insuperable technical difficulty, and numerical modeling[8] was used to analyze the consequences of monetary and foreign exchange policies.

3. Numerical results

First, we assume that the characteristics of demand do not differ between countries. We then assume that the quality of domestic production is lower than that of the foreign firm. This assumption may be justified by the fact that we consider the emerging economy to be the Home country, and we therefore expect the average quality of its output to be lower than in the more developed neighboring country. As far as simplifying procedures are concerned, we may fix variables characterizing the following numbers of brands: NhF, NNh, NfH and NNf, leaving just NhH and NfF as endogenous variables among those describing the product variety. This choice can be justified by considering the so-called medium run, in which the whole range of products cannot be changed[9].

Analysis starts with the assumption of zero monetary expansion and foreign exchange expansion rates.

The graphs below illustrate the results for the following numerical parameters of the model:

$c_H = 5$, $c_F = 4$, $AhH = 85$; $AfH = 95$; $AhF = 60$, $AfF = 90$, $\beta_H = \beta_F = 0.5$, $\gamma_H = \gamma_F = 0.3$

$\mu_H = \mu_F = 0.1$, $FC_H = FC_F = 100$, $r = 10\%$, $\rho = 15\%$

Here − is the share of the firms' expenditures associated with the interest rate.

Details on the computing procedure may be found in the Appendix.

Let us consider first the effects on the whole output of the country, which is displayed on Figure 1. Note that the measurement of expansion depends on
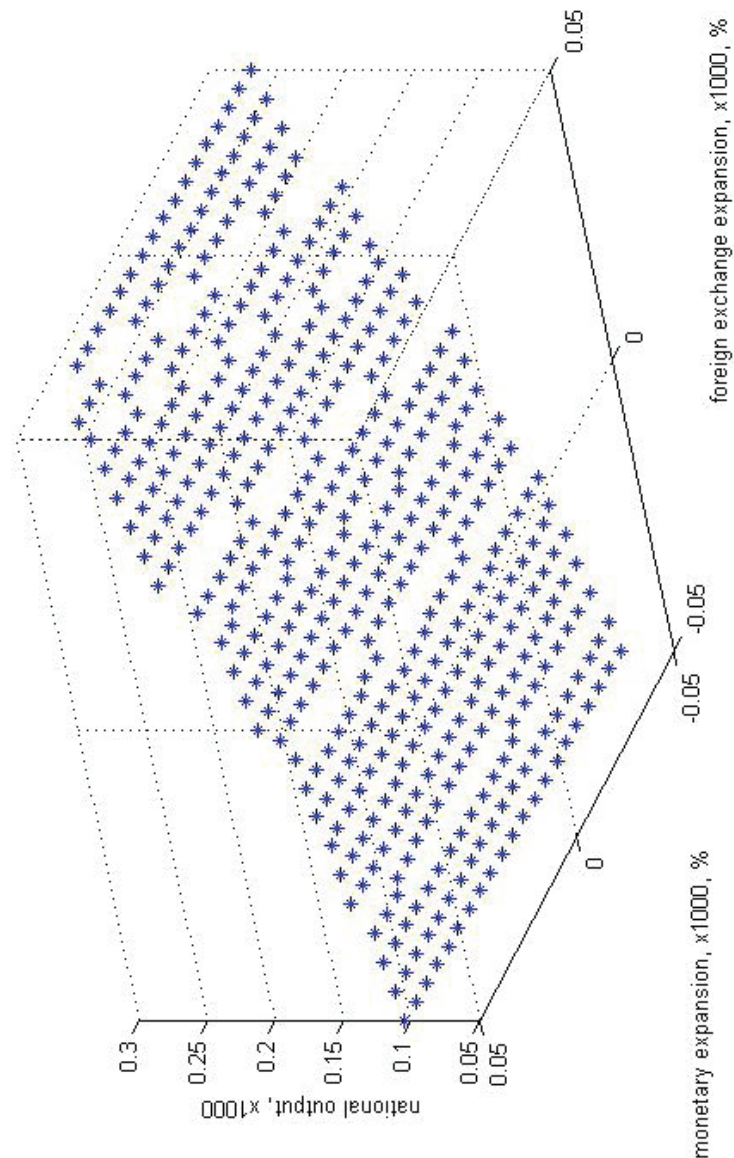
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[8] For more details see Appendix 1.
[9] For instance, export and import volatility is bound by contracts from the last period due to positive delivery time, etc. It also seems to be quite natural that the product range in the non-tradable goods sector does not change in the medium run. Therefore, all our results are limited by the time span they refer to.

Figure 1. Effects of monetary and foreign exchange expansions on the overall output of the country

the initial point, which was selected quite arbitrarily, so all inferences about the preferable absolute value of degree of expansion or contraction are meaningless, while it is the inferences about the marginal effects of expansion that are of interest.

The graph shows the well-known positive effect of monetary and foreign exchange expansions on the output in the economy. However, this only holds true if the real sector is assumed to retain its structural integrity.

3.1. Structural changes as a side effect of monetary and exchange rate policies

Let us consider, for instance, the effects of monetary expansion (Figures 2, 3).

In spite of the overall positive tendency, there is a break at a 15%-contraction, which is associated with a structural change in the economy.

Definition: A structural change in the real sector of the economy is a change in the product range (number of brands). If a product range is expanding, we will call it a positive structural change. If a product range is contracting, we will call it a negative structural change.

We can see that although a monetary expansion generally stimulates the real sector of the economy, structural changes can seriously undermine this effect. Similar patterns of behavior are observed regardless of initial conditions. The
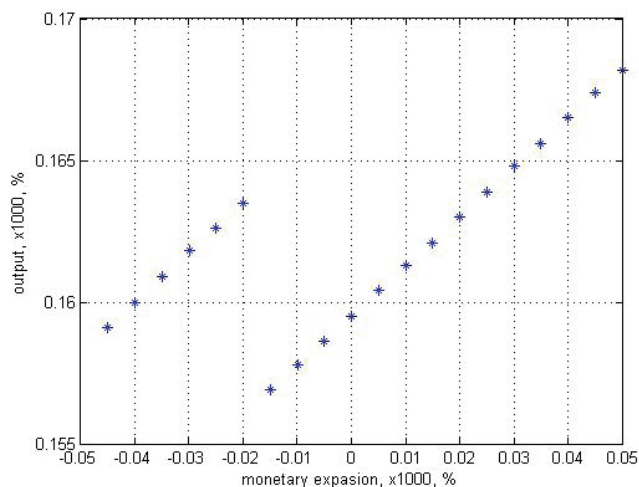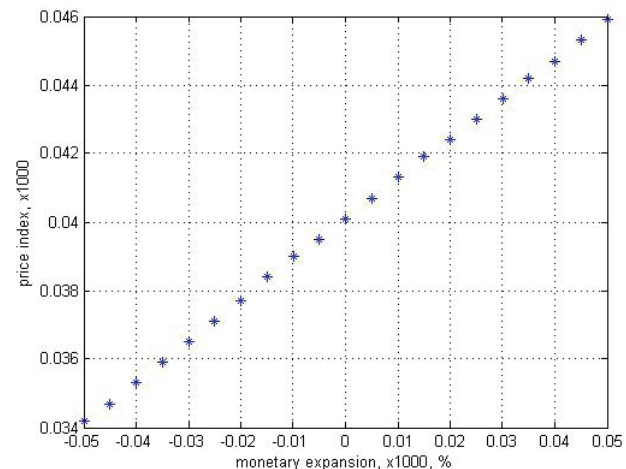
Figure 3. Effects of monetary policy expansion on domestic prices in the absence of foreign exchange expansion

intuition standing behind this phenomenon is as follows: monetary expansion stimulates demand both for home-produced goods and for foreign-produced ones, and the latter effect may be stronger because of the higher average quality of foreign-produced goods. Therefore, a substitution effect influencing both the optimal quantity of production for each brand and the optimal number of brands in consumption may be observed. Since the number of home-produced brands is assumed to be integer, a monetary expansion may have the traditional positive effect when the optimal number of home-produced brands does not change. Any additional demand will be split between the foreign and home brands in some proportion (favoring the higher-quality foreign brands). However, a cumulative effect on the optimal number of home-produced brands may sometimes lead to a reduction in the home set of brands. This implies a negative structural change in the real sector of the Home economy (which is observed as a break in Fig.2). In other words, given an increase in purchasing power, consumers will shift their choice in favor of higher quality foreign-produced goods, which may result in the replacement of cheap, lower quality home brands by more expensive, higher-quality foreign brands.

With regard to foreign exchange expansion, its effects on the output and average prices are given in Figures 4 and 5.

Foreign exchange expansion is an effective instrument for stimulating the real sector of the economy; however, it is also accompanied by the side
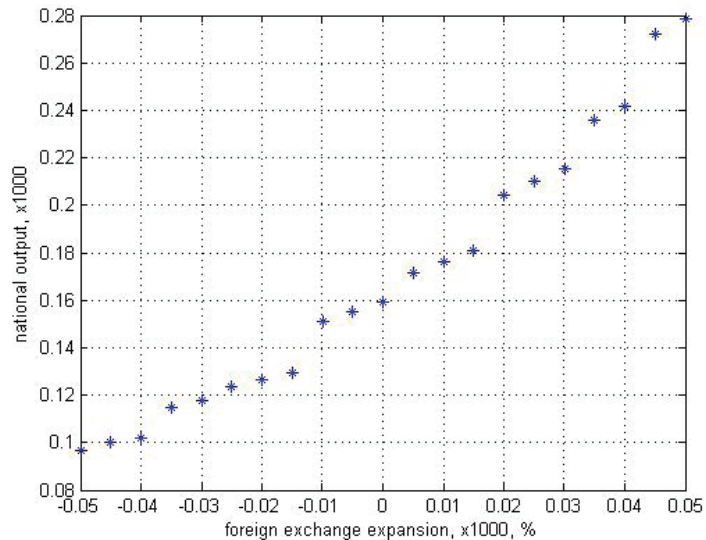
Figure 2. Effects of monetary policy on output in the absence of foreign exchange expansion

Figure 4. Effects of foreign exchange expansion on national output
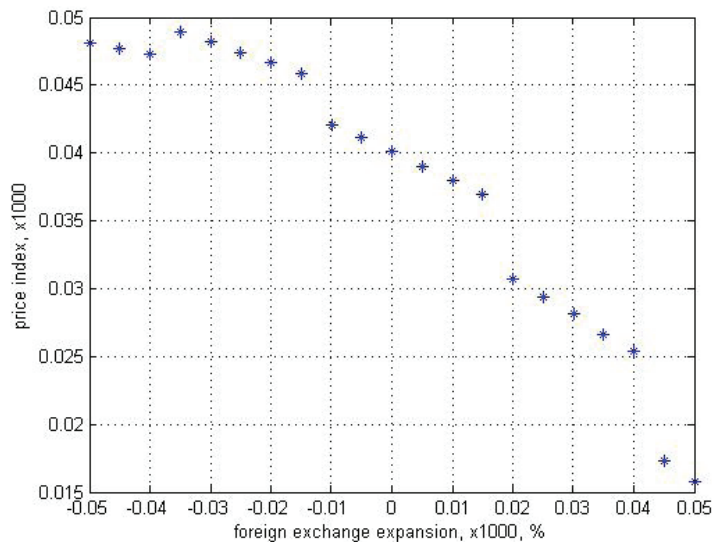in the absence of monetary expansion

Figure 5. Effects of foreign exchange expansion on the price index
in the absence of monetary expansion

effects of structural changes. These consequences are incurred by relative changes in (a) demand on the foreign market in terms of home currency and (b) costs in terms of home currency. In case of foreign exchange expansion, the first channel positively affects the export of the home country, thus being one of the origins of a growth in output. Also, it cannot be the source of structural breaks, because we have fixed the product range for international trade. Therefore, the roots of structural breaks lie in the tradable sector of the home economy through the second channel, changes in the costs of foreign-produced goods denominated in the home currency. Given a foreign exchange expansion, the increase in these costs will definitely have a negative effect on import and increase the output of the home producer in this sector, as well as the average price (these effects are present even in rather simple models of oligopoly, such as the standard Cournot duopoly). The growth in the output of the domestic producer (which may result in an increase both in the number of brands it produces and in the output of each brand) will be continuous, unless there is an expansion in the range of brands – what we have called a positive structural break.

Therefore, in contrast with monetary policy, the side effects of an exchange rate expansion are positive, because a growing exchange rate will positively affect the competitiveness of home-produced goods in terms of production costs.

3.2. Pass-through effect

Figure 5 demonstrates the possibility of structural changes to have both positive and negative pass-through effects. While the former is quite expected, the latter requires additional explanation. Worsening business conditions for import goods (resulting in the rise of prices and shrinkage in capacity) make the situation much more profitable for the home producer, who gains an additional market share through the increase in output. Given our choice of initial conditions, the home firm is characterized by lower quality and therefore faces lower equilibrium prices; this is the origin of the negative pass-through effect, which is reminiscent here of the adverse selection problem.

3.3. Diversification

Another interesting issue that is often neglected is the diversification of the home economy, which is also influenced by monetary and foreign exchange expansions. The effect of the former is rather complicated, since it depends on the competitiveness of the home economy. Computational modeling shows that if the quality of home's output is high enough, then stimulating demand
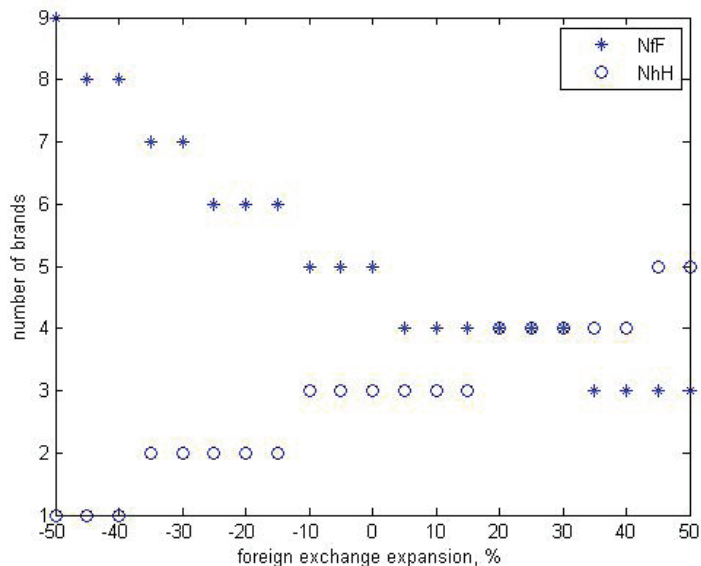
Figure 6. Effects of a foreign exchange expansion on home
and foreign diversification in the absence of monetary expansion

will result in an increasing diversification of the economy; if not, then national brands will simply be replaced by better foreign equivalents. An example of a foreign exchange expansion and its effect is shown on Figure 6.

Figure 6 shows that a foreign exchange expansion increases the diversification of the home economy (the numbers on the graph are for home and foreign brands in the national sectors of tradable goods) and has the opposite effect on the foreign economy. Of course, the number of products as a measure of product diversification is insufficient. For instance, Gollop and Monahan (1991) built a diversification index which also takes into consideration the distribution of sales of the produced goods and differences in the heterogeneity of products. However, after using this index on a large data set, they concluded that the "number component is the dominant force" in explaining corporate diversification (p. 327). This gives us some justification for focusing on the number of products, exogenously fixing the degree of product differentiation.

The overall analysis proved that the volatile structure of the real sector of economy should be taken into consideration when analyzing the prospects of monetary and foreign exchange policies, because it exercises significant effects on the consequences of both.

4. Comments on monetary and exchange rate policy

After the financial crisis of 1998, Russia was left with an undervalued national currency, and in the period 1998–2007 experienced a level of inflation higher than many of its trade partners. Along with the ruble's quite stable nominal exchange rate, this led to a gradual appreciation of the ruble's real effective exchange rate throughout this period. The necessity of sterilizing foreign exchange market interventions gradually decreased as the ruble appreciated.

An analysis of these stylized facts about Russian monetary policy in the context of the model described above reveals a new possible source of problems for the Bank of Russia and the Russian government. A less intensive foreign exchange expansion, accompanied by a less strict monetary contraction, will lead to a growing probability of negative structural changes in the real sector of the economy.

If monetary (credit) and foreign exchange policy change in opposite directions, the probability of structural changes in the real sector will increase. The structural changes will be:
- positive if the monetary policy contraction is accompanied by a foreign exchange expansion;
- negative if the monetary expansion is accompanied by a foreign exchange contraction (Russia after 1998).

If monetary (credit) and foreign exchange policy change in the same direction, there will be a decrease in the probability of structural changes in the real sector. Thus, if the Central Bank does not adopt an active foreign exchange policy in monetary regulation, then the foreign exchange market will become one of the channels by which monetary policy is transmitted to the real sector, and monetary and foreign exchange will always change in the same direction. This is why the problem analyzed in this article concerns more developing countries attempting to control both the monetary (credit) and foreign exchange spheres, rather than developed countries that are not attempting to manage the exchange rate.

With regard to Russia, we can see how very reasonable monetary management, based on the principle of gradual real exchange rate changes directed at attaining equilibrium, may lead to unexpected problems with the GDP growth rate and the unemployment rate.

5. Concluding remarks

This paper has analyzed the possible consequences of monetary and foreign exchange policies given a varying structure of the real sector of the economy. The analysis demonstrates that structural changes in the real sector are of paramount importance, and may be able under certain conditions to undermine the overall effect of the policy.

Another interesting result of this paper concerns the pass-through effect that may be either positive or negative depending on the initial set of parameters. A negative pass-through was explained by increasing market shares of low quality goods, which may happen in developing countries trying to defend their own producers by depreciating the home currency.

We then showed that monetary and foreign exchange policies also influence important parameters such as diversification of the economy. Provided home output has a sufficiently high level of quality, a foreign exchange expansion will result in the growing economy's diversification. However, if the quality is sufficiently low, the country may suffer from the opposite effect, because home products will be substituted by higher quality foreign brands.

Finally, we have found that the problem of structural changes concerns more developing countries (e.g., Russia) with monetary and foreign exchange policies changing in opposite direction, and less developed countries with more stable monetary and exchange rate policies. In particular, the transition from exchange rate targeting to inflation targeting may provoke negative structural changes in the real sector, because it usually requires an appreciation of the home currency along with an increase in the central bank's crediting activity.

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Appendix 1.
Algorithm for numerical modeling

The equilibrium is found in two stages: first the firms decide how many brands they want to produce for each market segment, and then determine the optimal output for each type of good.

We apply backward induction to solve this problem and start with the second step. We set the following values[10]:

$$c_H = 5, \quad c_F = 4, \quad AhH = 85; \quad AfH = 95; \quad AhF = 60, \quad AfF = 90, \quad \beta_H = \beta_F = 0.5, \quad \gamma_H = \gamma_F = 0.3$$

$$\mu_H = \mu_F = 0.1, \quad FC_H = FC_F = 100, \quad r = 10\%, \quad \rho = 15\%, \quad NNH = 6, \quad NhF = 2, \quad NfH = 2, \quad NNf = 6$$

and start with the assumption of zero monetary and foreign exchange expansion rates.

First order conditions for the profit maximization problems for both firms are as follows:

$$NhH \cdot \left(60 - \frac{1}{5}XhH - \frac{3}{10}NhH \cdot XhH - \frac{3}{5}XfH - \frac{3}{5}XNH\right) + NhH \cdot XhH \cdot \left(-\frac{1}{5} - \frac{3}{10}NhH\right) - \frac{3}{5}XNH \cdot NhH = 0$$

$$-\frac{6}{5}NhH \cdot XhH + 390 - 24 \cdot XNH - \frac{6}{5}XfH = 0$$

$$110 - \frac{16}{5}XhF - \frac{3}{5}XfF \cdot NfF - \frac{6}{5}XNF = 0$$

$$152 - \frac{16}{5}XfH - \frac{3}{5}NhH \cdot XhH - \frac{6}{5}XNH = 0$$

$$-\frac{6}{5}XfF \cdot NfF + 516 - 24 * XNF - \frac{6}{5}XhF = 0$$

$$NfF \cdot \left(86 - \frac{1}{5}XfF - \frac{3}{5}XhF - \frac{3}{10}XfF \cdot NfF - \frac{3}{5}XNF\right) + XfF \cdot NfF \cdot \left(-\frac{1}{5} - \frac{3}{10}NfF\right) - \frac{3}{5}XNF \cdot NfF = 0$$

Solving this system for XhH, XhF, XNh, XfF, XfH and XNF yields the following results:

$$XhH = 10\frac{633 + 559NfF}{314 + 351NfF}$$

$$XhF = \frac{35890}{314 + 351NfF}$$

$$XNH = 5\frac{888 + 845NhH}{314 + 351NfF} \tag{A1}$$

$$XfF = 5\frac{2349NhH + 2650}{314 + 351NNh}$$

$$XfH = \frac{17830}{314 + 351NhH}$$

$$XNF = 20\frac{421 + 162NfF}{314 + 351NfF}$$

Substituting (A1) into the initial profit functions, we find expressions depending only on two variables (the number of brands NfF and NhH):

$$\pi_H = 10NhH\frac{633 + 559NfF}{314 + 351NfF}\cdot\left(65 - 2\frac{633 + 559NfF}{314 + 351NfF} - 3NhH\frac{633 + 559NfF}{314 + 351NfF} - \frac{10698}{314 + 351NhH} -\right.$$
$$-3\frac{888 + 845NhH}{314 + 461NhH}\right) - \frac{1}{2}NhH^2 + 30\frac{888 + 845NhH}{314 + 351NhH}\cdot\left(65 - 10\frac{888 + 845NhH}{314 + 351NhH} - NhH\frac{633 + 559NfF}{314 + 351NfF} -\right.$$
$$-\frac{3566}{314 + 351NhH}\right) - 20 + \frac{71780}{314 + 351NfF}\cdot\left(55 - \frac{28712}{314 + 351NfF} - \frac{3NfF}{2}\frac{2349NhH + 2650}{314 + 351NhH} -\right.$$
$$-12\frac{421 + 162NfF}{314 + 351NfF}\right)$$

$$\pi_F = 5NfF\frac{2349NhH + 2650}{314 + 351NhH}\cdot\left(86 - \frac{2349NhH + 2650}{314 + 351NhH} - \frac{21534}{314 + 351NfF} - \frac{3NfF}{2}\frac{2349NhH + 2650}{314 + 351NhH} -\right.$$
$$-12\frac{421 + 162NfF}{314 + 351NfF}\right) - \frac{1}{2}NfF^2 + 120\frac{421 + 162NfF}{314 + 351NfF}\cdot\left(86 - 40\frac{421 + 162NfF}{314 + 351NfF} - \frac{7178}{314 + 351NfF} -\right.$$
$$-\frac{NfF}{2}\frac{2349NhH + 2650}{314 + 351NhH}\right) - 20 + \frac{35660}{314 + 351NhH}\cdot\left(76 - \frac{14264}{314 + 351NhH} - \frac{3NhH}{2}\frac{633 + 559NfF}{314 + 351NfF} -\right.$$
$$-3\frac{888 + 845NhH}{314 + 351NhH}\right)$$

The system

$$\begin{cases} \dfrac{\partial \pi_H}{\partial NhH} = 0 \\ \dfrac{\partial \pi_F}{\partial NfF} = 0 \end{cases} \tag{A2}$$

was then numerically solved for NhH and NfF using Matlab 2007.

Results were then rounded off and substituted into (A1). This procedure was used to find all the other variables given above.

From a technical point of view, rounding off NhH and NfF is the source of structural changes, because the parameter of diversification of the companies is not continuous.

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[10] Some substantiation of these figures is given in the text of the article.

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при анализе монетарной политики**

(на английском языке)