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Purchasing power parity and the Balassa-Samuelson effect in emerging economies

Dissertation proposal

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Abstract

In this paper I propose my future research on the role and significance of purchasing power parity (PPP) and the Balassa-Samuelson (B-S) effect in Central and Eastern European countries in the process of accession to the European Monetary Union (EMU). In the first chapter of my dissertation I would like to improve Lo's (1991) modified rescaled range test and the rescaled variance test by Giraitis *et al.* (2003) to account for structural breaks. Afterwards, these improved tests are used to investigate whether PPP does hold in emerging countries or not. The second chapter develops a two-sector dynamic stochastic general equilibrium (DSGE) model of a small open economy with sticky prices, productivity growth and with alternative modeling of PPP, which depends on the outcome of the first chapter. Particularly, the main goal is to asses the contribution of the B-S effect on emerging countries' ability to comply with the Maastricht accession criteria before entering EMU. In the third chapter, I would like to extend the previous DSGE model for the endogenous B-S effect, which would be fully microfounded on heterogeneous firms with differential productivity level.

Contents

Introduction

The proposed research focuses on the role and significance of purchasing power parity (PPP) and the Balassa-Samuelson (B-S) effect in emerging economies. More specifically, our interest lies in whether PPP holds or not for the case of Central and Eastern European (CEE) countries, and furthermore we are concerned in the implications of the B-S effect for the emerging countries' ability to meet the Maastricht accession criteria[1] before entering the European Monetary Union (EMU).

The first chapter is devoted to the investigation of PPP relationship for CEE countries. In order to perform empirical analysis we firstly point out that it is necessary to run such tests that do account for structural breaks within the exchange rate data otherwise tests of stationarity might be biased towards erroneous non-rejection of the unit root hypothesis. Particularly, we would like to improve two non-parametric tests: Lo's (1991) modified rescaled range test and the rescaled variance test by Giraitis *et al.* (2003) to account for structural breaks. To our knowledge, such non-parametric tests that would explicitly control for structural breaks have yet to be developed. Finally, after the development of the tests we would test the PPP hypothesis for CEE countries. Essentially two outcomes may arise: validation of PPP or its rejection.

In the second chapter, we would like to quantitatively asses the contribution of the B-S effect on the ability of emerging countries to satisfy the Maastricht criteria before entering EMU. For this reason, we develop a two-sector dynamic stochastic general equilibrium (DSGE) model of a small open economy with nominal price rigidities, imported intermediate inputs, complex investment activity, and differential productivity growth in the tradable and nontradable sectors. In addition, we allow two alternative specifications of PPP relationship, which depends on the outcome of the first chapter. The proposed model would be calibrated for the case of the Czech Republic.

Subsequently, we would investigate impulse response functions to the B-S productivity type shock to evaluate possible compliance with the inflation criterion. Following Natalucci and Ravenna (2005) we also compare the inflation/exchange rate variance trade-offs under different monetary policy rules to determine if fulfilling both ERM II and the inflation criterion is manageable. Additionally, we could derive central bank's loss function from a second-order approximation to the utility function of the representative household, and contrast the welfare implications of alternative monetary policy rules.

The third chapter would try to extend the previous DSGE model for the endogenous B-S effect in the fashion of the recent study by Ghironi and Melitz (2005). Specifically, we would introduce heterogeneous firms which differ in their productivity level. This extension would

[1] Our interest is in the inflation criterion, and Exchange Rate Mechanism (ERM II) criterion, that requires limited movements of the exchange rate to the euro (+/-15%).

result in so called endogenous nontradedness feature where the set of traded and nontraded goods can evolve over time; a pattern that is more consistent with the data.

1 Revisiting the purchasing power parity puzzle

1.1 Motivation

According to monetary theory, purchasing power parity[2] (PPP) holds in the long run, this implies that shocks to the real exchange rate have only a transitory effect. Evidence of long-run PPP can be revealed in the real exchange rate by stationarity tests also called unit root tests. In today's global and free market environment it is hard to believe that shocks to the real exchange rate would have permanent effect. In other words, it is unlikely that the real exchange rate may follow a random walk process, which is non-stationary and contains a unit root. Nonetheless, due to some frictions such as transaction and trade costs, price stickiness, taxation, subsidies, market interventions, market segmentation, and trade restrictions; PPP might not hold exactly in the short-run but should still emerge in the long-run basis. If the PPP is to hold in the long run, there should be some evidence in favor of long-term dependence in the real exchange rate data, and thus to reject a unit root. The presence of long-term dependence in the data has important implications because it indicates evidence of nonlinear dependence in the first and second moments and, therefore, is evidence of predictability. Predictability would undermine the weak-form efficiency of foreign exchange market, since long-term memory in exchange rate returns would imply the possibility to earn speculative profits.

A lot of effort has been already put into investigating the behavior of foreign exchange rates to finding some presence of long-term memory in order to validate PPP. However, empirical research in general has not provided a clear consensus for or against long-run PPP. Why are the empirical results so ambiguous? In what will follow, by inspecting the previously applied methodologies I will point out that the presence of structural breaks within foreign exchange rate data might have biased the results of the unit root tests towards erroneous non-rejection of the unit root hypothesis.

Older empirical studies, which use a single-equation test for a unit root, have generally not been able to reject random walk behavior of foreign exchange rates (Adler and Lehmann, 1983; Baillie and Bollerslev, 1989; Coleman, 1990; among others). This means non-stationarity of the exchange rate time series contains a unit root and does not possess any clear long-term memory pattern. On the contrary, more recent studies using panel data techniques found evidence in favor of long-run PPP (Jorion and Sweeney, 1996; Papell and Theodoridis, 1998; Sarno and Taylor, 1998). However, these panel data studies suffer from several drawbacks. Mainly, the results are quite sensitive to what particular countries are included in the panel

[2]The strong version of PPP states that a common basket of goods, when quoted in the same currency, costs the same in all countries. Alternatively, the weaker version of PPP states that the rate of change in the nominal exchange rate equals the difference between the growth rate of domestic and foreign price index.

sample, depending on the fraction of the series that are stationary in the panel, and how an alternative hypothesis is postulated. There are a few recent studies which employed alternative non-parametric tests such as the modified rescaled range test and the variance test (Bhar, 1993; Pan, Liu, and Bastin, 1996; Ahking, 2004; and others) but with results which again do not provide unambiguous support for long-run PPP.

More relevant is that the above studies do not explicitly tackle the issue of *structural breaks* within foreign exchange rate data. It was noted that if structural breaks were present in the data but not allowed for in the specification of an econometric model, the results would be biased towards erroneous non-rejection of a unit root (Rappoport and Reichlin, 1989; Perron, 1989). The reason comes from the permanent nature of the structural change. If a permanent change is not modeled in the underlying process, then the unit root test will treat it as a shock with a permanent effect. Shocks have permanent effects only in time series with unit roots. Thus, the results will be biased towards finding unit roots, even though the time series in question are stationary with an exogenous structural change. In this light, the validity of studies which disregard structural breaks in the data is questionable.

There are only a few studies which account for structural breaks when analyzing long-run PPP. In the study by Hegwood and Papell (1998), the authors allowed for multiple structural breaks in the Perron-Vogelsang test[3]. They detected so called quasi purchasing power parity around a mean which shifts due to the presence of structural breaks. In contrast, Baum, Barkoulas, and Caglayan (1999) modified the Perron-Vogelsgang test for the presence of fractional integration or structural breaks[4] and gained results against long-run PPP. Additional motivation for the importance of modeling structural breaks comes from the recent study of Papell (2006). Papell generates panels of exchange rate data to investigate what data generating processes are consistent with patterns found in the actual data for the US dollar. Fitting several processes such as the stationary autoregressive (AR) process, the mixture of unit root and stationary AR process, threshold AR process, exponential smooth transition AR process; the best congruence is found in case of level stationarity with PPP restricted structural change, where the pre- and post-break means are restricted to equal.

In this light, there is a vital space for the development of further comprehensive tests that do account for the presence of structural breaks within the data. Particularly, one might extend non-parametric tests for the presence of structural breaks to strengthen the consistency of empirical results from the perspective of the structural breaks issue. Hence, one might be able to confirm long-run PPP through the other tests which incorporate structural breaks as well, and solve the PPP puzzle. However, if long-run PPP were not validated by newly developed tests which account for structural breaks, this would unfortunately bring another piece into the PPP puzzle. This would suggest that even though controlling for structural breaks in the

[3]Perron and Vogelsang (1992).

[4]Particularly, Baum *et al.* allowed for two possible structural breaks.

data there still exist permanent deviations from PPP, which have some underlying economic reasons.

In the next section I will closely review the relevant empirical literature about PPP, what has been done to date, and also some indirect contributions, which might be exploited to improve the identification of PPP. Critical assessment will reveal important mistakes or potential pitfalls one should avoid in future research as well. Methodological issues and expected outcome are presented afterwards.

1.2 Detailed literature review

As was mentioned earlier, several recent studies which use panel data technique, have found evidence in favor of long-run PPP. However, these favorable results are subject to the choice of concrete countries included and depend on the size of the panel. Evidence of long-run PPP tends to be stronger when high inflation countries are selected into the panel (Rogoff, 1996). Furthermore, the size of the panel and the fraction of stationary series can produce significantly different results. Karlsson and Lothgren (2000) found that for panel data with a short time span, the unit root is often not rejected when a large fraction of the series is stationary. On the contrary, in case of large time span the unit root is often rejected when only a small fraction of the series is stationary. In addition, the actual specification of the alternative hypothesis of the unit root test plays a crucial role since a unit root can be rejected even if only one of the real exchange rate series in the panel is stationary (Taylor and Sarno, 1997). Thus, one should prefer to carry out several alternative tests before the final judgment: e.g. Taylor and Sarno (1998) suggest a complementary unit root test where the null hypothesis is rejected only if all the series are stationary. Very often a crucial mistake in previous panel data studies is their failure to control for cross-sectional dependence in the data. In this light, their validity should be disregarded (Engel, Hendrickson, and Rogers, 1997; O'Connell, 1998) since real exchange rates are highly correlated. Hence, although panel unit root tests are quite powerful, their use must be accompanied with great caution because one can easily get into the pitfall as noted in previous examples.

Identification of long-run PPP can be done by applying non-parametric tests as well, and these tests have several advantages over conventional parametric tests. They allow for quite general functional specification of the model, and the error term need not follow a standard Gaussian process. Two non-parametric tests, the Lo's (1991) modified rescaled range test and the rescaled variance test of Giraitis *et al.* (2003), were employed by Ahking (2004) to examine the long-run behavior of real exchange rates in order to validate long-run PPP. He found only two cases out of fifteen where a unit-root process is rejected in favor of long-term dependence using the modified rescaled range test, and only one case with the rescaled variance test. The main shortcoming of Ahking's methodology, however, is that it does not explicitly account for

the presence of structural breaks in the exchange rate data, which might lead to less favorable and biased results as already noted in the introduction. In this way, applied tests in the study by Ahking should be firstly revised to solve for the problem of structural breaks in the time series, and then these improved test could be applied on raw data. The extension of non-parametric tests to allow for structural breaks is also vital space for my research.

Similarly, Pan, Liu, and Bastin (1996) applied the heteroskedasticity-robust variance-ratio test[5] and the modified rescaled range test to inspect the short- and long-term dependence in selected series of real and nominal exchange rates. With nominal exchange rates the results indicate the presence of long-term memory patterns whereas with real exchange rate data there is no clear evidence of long-term dependence. Arising inconsistency might be partly attributable to the different frequency of data available for real and nominal exchange rates. However, by the same token as in the previous study I would primarily suspect the presence of structural breaks within the data which led to erroneous non-rejection of the unit root hypothesis in case of real exchange rates. Hence, one might choose better methodologies which would account for structural breaks to gain more consistent results. But, there is a lack of such methodologies yet. So, this gap in the methodologies I would like to address in my proposed research.

There are, fortunately, a few studies which modified unit root tests for the presence of structural breaks. Hegwood and Papell (1998) extended the Perron-Vogelsang test allowing for multiple structural breaks and they found the real exchange rate data to be stationary, in other words validating PPP. However, stationarity is detected around a mean which shifts due to the presence of structural breaks. They call this result quasi purchasing power parity. In a similar way, Baum *et al.* modified the Perron-Vogelsang test for the presence of both fractional integration and structural breaks, but contrary to the Hegwood and Papell finding, their results provide evidence against long-run PPP. One possible explanation why these contradictory results emerge using the same underlying test is the fact that fractional integration and structural changes might play a more significant role which previous work has failed to capture. In particular, fractional integration allows for more general specification of underlying data generating process, and therefore should be preferred in applied work. This puzzling issue, when one underlying test can produce two conflicting results, could be resolved by the construction of other tests which would account for the presence of fractional integration and structural breaks as well. A good choice might be the modification of non-parametric test procedures such as the modified rescaled range test and the rescaled variance test. Stressing the main message again, the tests of long-run PPP need to be redesigned to allow for structural breaks and possibly also for fractional integration, which constitutes one of my tasks in the first chapter of my dissertation.

In this part, I would like to assess some of the indirect contributions in the area of structural

[5]Devised by Lo and MacKinlay (1988).

breaks, which are closely related to my proposed research and its justification. Firstly, a common weakness of the previous studies is that in order to increase the power of applied tests they use the longest time spans possible. However, it is likely that long time spans involve several structural breaks which may considerably bias the results when possible structural breaks are not explicitly modeled. Secondly, Granger and Terasvirta (1999) pointed out that estimates of long-term memory patterns depend on the number of switches[6], and where they occur within the sample. Usually, there is a positive relationship between the length of time span and the occurrence of structural breaks. Hence, I would suggest selecting a shorter time span which does not involve a lot of structural breaks (e.g. three breaks or less), and which do not occur close to the beginning or the end of the sample. Thirdly, an exchange rate regime switch may not always represent a true structural break. This is documented by Kočenda (2005), who recognized that for some of the European transition countries a structural break in the exchange rate occurred even several months before the exchange rate regime was revised. Therefore, a structural break does not necessarily always coincide with a change in the exchange rate regime. Thus, when analyzing foreign exchange rate data one should more accurately incorporate structural breaks and where the exact date of the structural break is also set in the style of Kočenda (2005) application.

The last thing to mention here is the importance of the chosen base currency, and its consequences on occurrences of structural breaks. Particularly, there are some arguments that failures to find favorable evidence for long-run PPP may be due to the use of the U.S. dollar as the base currency (Lothian, 1998; Papell, 2002). In the case of the U.S. dollar, there were found two almost equally offsetting structural breaks in the beginning and mid eighties, which might cause serious trouble in previous studies. The study by Papell and Theodoridis (1998) uses both the U.S. dollar and the German mark as base currencies, and the authors found stronger evidence for long-run PPP when the mark is used as base currency. This more favorable evidence might arise because the movements of the German mark within the period under consideration were limited by the bounds of the basket peg regime. Hence, the German mark is likely to involve fewer structural breaks in comparison with the U.S. dollar, and might be a better candidate for analyzing long-run PPP. In this light, one recommendation is to use several base currencies in the analysis in order to gain more consistent and exhaustive results among several base currencies. On the other hand, a more precise way would be to control for structural breaks in foreign exchange rate data for every base currency used.

[6] can be treated as breaks

1.3 Data and methodology

At the beginning of the project, exchange rate data will be collected[7] for the following emerging countries under consideration: Czech Republic, Slovakia, Poland, and Hungary. The reasons why I have chosen these particular countries is that all of them share a lot of similar political, historical and economic features and have foregone almost identical transition processes. For comparison purposes with previous studies exchange rates of the U.S. dollar, Euro, British pound, and the German mark will be investigated as well. My main interest is in monthly data for real exchange rates and daily data for nominal exchange rates that cover the largest possible span. For every country several base currencies will be taken, i.e., foreign currencies per U.S. dollar, per German mark, per British pound, etc. Due to the introduction of the Euro in 1999 further recalculations of exchange rates will be necessary which are related to currencies that were joined together in the Euro (e.g., for the German mark).

Further, structural breaks within exchange rate data will be detected using the technique developed by Bai and Perron (1998). This technique has significant advantages. It allows for multiple structural breaks within data, and the dates of structural breaks are not imposed *ad hoc* but are determined endogenously. However, there is still possibility to link resulting dates of breaks with some events that seriously affected the economy. Alternatively, the test due to Hansen (2000) can be used for the detection of structural breaks. In addition to the former test it allows for stochastically trending regressors. Having the dates of structural breaks the exchange rate time series can be divided into several subperiods.

In the next step ADF and KPSS tests[8] would be employed on corresponding subperiods to test for their stationarity. If data are found to be non-stationary, then further analysis would be done with the first differences of the exchange rates time series, which are likely to be found as stationary.

The most difficult part of the proposed research in this first chapter would be the development of nonparametric tests that would account for structural breaks. Two non-parametric tests, namely the modified rescaled range test and the rescaled variance test were chosen as the building baseline. These two non-parametric tests are suitable since they are quite powerful for detecting long-term memory patterns, both of them share similar application procedure to data, and in the final stage of the research they will allow for double checking the consistency of results. Let me briefly introduce the above mentioned tests.

The rescaled range or R/S analysis was firstly developed by Hurst (1951), and later refined by Mandelbrot and Wallis (1969). Lo's (1991) modified R/S test statistic accounts for possible biases that might be caused by short-term dependence and heteroskedasticity in a time series.

[7] The data can be obtained from www.cnb.cz (Czech National Bank web page) or www.nbs.sk (National Bank of Slovakia).

[8] Introduced by Said and Dickey (1984) and Kwiatkowski, Philips, Schnidt and Shin (1992).

The modified R/S test statistic has the following form:

$$Q_{i,n}(q) = \frac{\max \sum_{j=1}^{n} (X_{i,j} - E(X)_i) - \min \sum_{j=1}^{n} (X_{i,j} - E(X)_i)}{\sigma_{i,n}(q)} = \frac{R_i}{\sigma_{i,n}(q)}, \tag{1}$$

where

$$\sigma^2_{i,n}(q) = \frac{1}{n}\sum_{j=1}^{n}(X_{i,j} - E(X)_i)^2 + \frac{2}{n}\sum_{j=1}^{q} w_j(q) \left[\sum_{l=j+1}^{n}(X_{i,l} - E(X)_i)(X_{i,l-j} - E(X)_i)\right]$$

$$= \hat{c}_0 + 2\sum_{j=1}^{q} w_j(q)\hat{c}_j, \tag{2}$$

R_i is the range of the cumulative deviations of $X_{i,j}$ from its sample mean, q is the bandwidth parameter, and $\hat{c}_j$ is the jth order sample autocovariance and $w_j(q) = 1 - \frac{j}{q+1}$, q<n, are the Barlett window weights. Since $Q_n(q)$ grows without bound as n increases, therefore it is normalized to

$$V_n(q) = \frac{Q_n(q)}{\sqrt{n}}. \tag{3}$$

The limiting distribution of $V_n(q)$ is derived and tabulated in Lo (1991).

Giraitis *et al.* (2003) proposed the rescaled variance test or V/S statistic which is computed as

$$M_n(q) = \frac{\widehat{Var}(S_1^*, ..., S_N^*)}{n\widehat{\sigma_n^2}(q)}, \tag{4}$$

where $S_k^* = \sum_{j=1}^{k}(X_j - \bar{X})$ are the partial sums of $\{x_t\}$, and $\widehat{Var}(S_1^*, ..., S_N^*) = \frac{1}{n}\sum_{j=1}^{n}(S_j - \overline{S}^*)$ is their sample variance. The V/S test is more appropriate for time series that exhibit high volatility and is less sensitive to the choice of the bandwidth parameter q.

Now, I will describe the basic idea how to extent these tests to account for structural breaks. After structural breaks are specified within the sample, a trimming procedure would be applied; that means that data close to the specified structural break will be simply disregarded. However, this gives rise to several difficulties. Firstly, how much data should be disregarded around the structural breaks? Furthermore, the above testing techniques work in the way that in the first stage they divide the whole sample into non-overlapping subperiods with precisely specified length, and then the corresponding statistic is computed within each of

these subperiods. In a subsequent step, the specified length of non-overlapping subperiods is increased, so it is possible to divide the whole sample into integer number of subperiods again. In the presence of structural break, idea of trimming would lead to the fact that at least one of such subperiods has to be dropped out of consideration. Performing this it is unlikely that the limiting distribution of computed statistic remain unaffected. Therefore, additional recalculations would be necessary, presumably involving Monte Carlo simulations where exogenously specified dates of structural breaks would be incorporated.

1.4 Preliminary results

So far, I have applied a modified rescaled range test on the nominal daily exchange rate series of the Slovak Crown (SKK) with respect to several base currencies (US dollar, British Pound, Japanese Yen, Czech Crown) covering the period between 1994 and 2003. There is one significant structural break involved in the time series. This structural break happened in October 1998, when the National Bank of Slovakia abandoned a fixed exchange rate regime for a floating one, and therefore the whole sample can be divided into two subperiods: before the break (Pre-Oct1998) and after the break (Post-Oct1998). The results are presented in Table 1. I also include computed $V_n(q)$ statistic for the whole period.

Table 1
$V_n(q)$ test statistic for Slovak crown (SKK)[9]

	SKK/US	SKK/GBP	SKK/YEN	SKK/CZK
V(q_A) whole period	1,1350	1,0829	1,1496	1,1636
P(V< V(q_A))	0,3672	0,2901	0,3890	0,4100
V(q_A) Pre-Oct1998	1,0619	1,0949	1,2094	1,0810
P(V< V(q_A))	0,2610	0,3073	0,4794	0,2875
V(q_A) Post-Oct1998	1,1111	1,0851	1,0750	1,1671
P(V< V(q_A))	0,3315	0,2932	0,2792	0,4153

Inspecting gained results none of the computed statistics is significant. Thus, modified rescaled range test is unable to recognize the nominal exchange rate of SKK from the unit root process. However, several important observations should be stressed. Since the whole period comprises a structural break the resulting statistic might have been biased towards erroneous non-rejection of the unit root hypothesis, and thus its validity is questionable. On the other hand,

[9]The optimal bandwidth parameter q was set according to Andrews's (1991) data-dependent rule:
$q_A = [k_n]$, $k_n = \left(\frac{3T}{2}\right)^{\frac{1}{3}} \cdot \left(\frac{2\hat{\rho}}{1-\hat{\rho}^2}\right)^{\frac{2}{3}}$,
where $[k_n]$ is the integer value of k_n, $\hat{\rho}$ is the first-order autocorrelation coefficient, and T is the length of the time series.

the length of the time series of corresponding two subperiods might not have been sufficiently long enough to detect the long-term memory pattern. Therefore, it is quite challenging to extend the previously mentioned testing techniques that would account for structural breaks while not losing the information coming from the whole sample.

1.5 Expected outcome

In the first chapter of my dissertation I would like to improve the modified rescaled range test and the rescaled variance test by accounting for possible structural breaks. To my knowledge, such non-parametric tests that would explicitly control for structural breaks have not yet been developed. Having in mind the advantages of non-parametric tests which might be widened by the inclusion of possible structural breaks is tractable combination that would result in a more comprehensive and powerful test that could reveal long-term dependencies more accurately. Its potential application would cover many areas with the structural breaks issue, including PPP theory as well. One might be able to validate long-run PPP through the newly developed tests which incorporate structural breaks, and so successfully resolving the PPP puzzle. On the other hand, the opposite outcome may arise. That is, even though using powerful econometric tests that explicitly account for structural breaks in the data PPP is found not to hold in the long-run. This would support the view that there are permanent deviations from PPP, which should reflect some fundamental economic reasons. These economic reasons might include the presence of transaction and trade costs, rigidity of export and/or import prices, taxation, production subsidies, market interventions, international market segmentation, and other trade restrictions, and should be properly incorporated into the economic models. This represents also one of my tasks in the following chapter.

2 A small open economy with the Balassa-Samuelson effect

2.1 Motivation

New European Union (EU) member countries[10] are expected to join the European Monetary Union (EMU) in the coming years, and adopt the euro as a single official currency. Prior to adopting the euro, a member state has to achieve exchange rate stability by participating in European Exchange Rate Mechanism (ERM II) for at least two years. In addition, the Maastricht inflation criterion[11] is required to be met. So far, Cyprus, Estonia, Latvia, Lithuania, Malta, Slovakia and Slovenia have entered the ERM II system and chosen a strategy of fast adoption of the euro.

However, there are several reasons why the fast entry strategy might not be very advantageous. One of the main issues is potential problems to comply with Maastricht inflation criterion due to the presence of the Balassa-Samuelson (B-S) effect[12]. The B-S effect implies higher inflation rates, so the fast adoption of the euro can be translated into lower short-term interest rates (ECB, 2004). Consequently, demand and asset price booms can harshly hit the economy. Furthermore, since the B-S effect is reflected in appreciating currencies as well new EU member countries may face a trade-off between complying with the Maastricht inflation criterion and limiting movements of the exchange rate to the euro in the ERM II system (Buiter and Grafe, 2002; Begg, Eichengreen, Halpern, von Hagen, and Wyplosz, 2003).

The economic debate in the literature has predominately focused on the magnitude, causes and consequences of the B-S effect within non-optimizing frameworks. This, for example does not allow for the assessment of the quantitative welfare implications of alternative monetary policy rules within general equilibrium framework. So far, there are only a few studies that build a dynamic stochastic general equilibrium models (DSGE) for CEE countries which do address the implications of the B-S effect. Natalucci and Ravenna (2005) construct a two-sector DSGE model of a small open economy which is calibrated for the Czech Republic. The authors conclude that in the presence of B-S effect there is no monetary policy that would allow for the fulfillment of both ERM II criterion and the Maastricht inflation criterion. Similarly, Masten and Coricelli (2005) build a rather simple two-sector DSGE model calibrated for the Czech Republic. On the contrary, they found that the B-S effect is not a threat to fulfill the Maastricht inflation criterion when monetary policy is committed to an inflation

[10] Ten new countries - Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Slovakia and Slovenia – entered the EU on May 1^{st} 2004.

[11] The annual inflation rate must not exceed by more than 1.5% the average of the three lowest inflation countries in the euro area.

[12] Originated in the works by Balassa (1964) and Samuelson (1964). The B-S effect is based on differential productivity growth in tradable and nontradable production sectors. The countries with higher productivity in tradable sector relative to nontradable sector have on average higher price levels, higher inflation rates, and appreciating real exchange rates.

objective. Nevertheless, these studies suffer from significant drawbacks which might have led to ambiguous outcome about the implications of B-S effect for the emerging countries' ability to meet the Maastricht accession criteria.

The main drawback in Natalucci and Ravenna (2005) is an inappropriate simulation of the B-S experiment in the model, where a stationary productivity process in the tradable sector is deviated too far from equilibrium. As a consequence real exchange rate appreciation due to the B-S effect is not an equilibrium process. This issue is corrected in Masten and Coricelli (2005), where permanent nonstationary sector-specific shocks are introduced, and the real exchange rate appreciation is an equilibrium process. But the model in this study is quite problematic, and therefore questionable. Particularly, in comparison to the model of Natalucci and Ravenna (2005), here the authors abstract from modeling complex investment activity and imported intermediate inputs[13], and thus omit important features peculiar to CEE countries. Another concern resides in the assumption of exogenously specified negative externality in the production costs. This assumption turns out to be a very convenient way of how to generate improving terms of trade in the model, thus to be consistent with observed patterns in the data, but on the other hand is very *ad hoc* and without some exact economic foundation. Pointing out the problematic parts of the above mentioned studies there is still a huge space for the development of more comprehensive DSGE model for CEE countries. This is a challenge I would like to address in the second chapter of my dissertation.

Specifically, I will build a two-sector DSGE model of a small open economy, which would be calibrated for the Czech Republic. Natalucci and Ravenna (2005) would represent the closest model to the one developed in this chapter. However, several significant departures are considered. First, the B-S effect would be simulated in the spirit of Masten and Coricelli (2005), that is, permanent nonstationary productivity shocks are introduced in traded and nontraded sector. Secondly, depending on the outcome of the first chapter, whether PPP is validated or not, we would correspondingly modify the setup of the foreign sector. If PPP is found to be valid, perfect competition in the tradable sector is assumed, so the law of one price holds. On the other hand, if PPP is not validated, the departures from PPP are built in through the nominal price rigidities in the tradable sector and by imperfect pass-through from exchange rate movements to the domestic currency prices of imports.

After the model is built we would derive central bank's loss function from a second-order approximation to the utility function of the representative household. We will find an optimal monetary policy in this economy and contrast the welfare implications of alternative monetary policy rules. The main goal of this chapter would be to evaluate the implications of the B-S effect on the ability of emerging countries to satisfy the Maastricht criteria. Particularly, we would investigate impulse response functions to the B-S productivity shock to analyze possible

[13]For example, in the Czech Republic intermediate goods represent more than 50% of all imports. It is also suggested by McCallum and Nelson (2001) to allow imported goods to enter both consumption and production.

compliance with the inflation criterion. Moreover, as in Natalucci and Ravenna (2005), we can analyze the inflation/exchange rate variance trade-offs under different monetary policy rules to see if it is manageable to jointly fulfill ERM II and the inflation criterion. Finally, we would assess the robustness of the results with respect to changes in model parameters.

The remainder of this chapter is organized as follows. In the next section we address recent relevant literature concerning the B-S effect. Afterwards we present a model and describe research methodology. Possible extensions of the model complete this chapter.

2.2 The Balassa-Samuelson effect in recent literature

There is a wide array of papers that empirically investigate the extent of the B-S effect for CEE countries. The B-S effect is often found to be relatively small, explaining only a small fraction of observed inflation differentials between the new EU member countries and the Euro area. For example, Wagner and Hlouskova (2004) report the value around 0.5 % and Mihaljek and Klau (2003) conclude that productivity differentials explain only between 0.2 and 2.0 % of inflation differentials. There are several issues that make the estimates of the B-S effect imprecise. The large share of food items and the low share of nontradables in the consumer price index (CPI) may attenuate the extent of the B-S effect (Egert, Drine, Lommatzsch, and Rault, 2003). Further, large proportion of administrated and regulated prices in CPI can account for an important share of excess inflation (Cihak and Holub, 2001). Some authors argue that the small extent of the B-S effect can be attributable to the fact that PPP does not hold for tradable goods (Blaszkiewicz, Kowalski, Rawdanowicz, and Wozniak, 2004; Lojschova, 2003). PPP for tradable goods may not hold since many prices of tradable goods involve nontradable components (rents, distribution services, advertising, etc.). In this light, part of the increase in tradable good prices can be implicitly explained by the B-S effect.

The discussion in the literature focuses less on the implications of the B-S effect in DSGE models. We have already mentioned two relevant contributions in the motivation section (Natalucci and Ravenna, 2005; Masten and Coricelli, 2005), which address the consequences of the B-S effect on the ability of emerging countries to meet the Maastricht criteria. Further, Devereux (2003) develops a DSGE of a small open economy with rigid prices and wages to examine the adjustment process following EU accession in the presence of capital inflow and productivity shocks. He identifies the following transition problems after adopting the euro as a single currency: large foreign borrowing, high wage inflation, excessive boom in stock market, and too rapid growth in nontradable goods sector at the expense of the traded goods sector. However, these inefficiencies can be overcome by application of alternative monetary policies. Particularly, the policy of flexible inflation targeting with weight on exchange rate stability seems the best. Laxton and Pesenti (2003) build a DSGE model of large complexity to assess the effectiveness of alternative Taylor rules in stabilizing variability in output and

inflation. Their model is calibrated for the Czech Republic, and the authors found that inflation-forecast-based rules perform better than conventional Taylor rules.

The recent paper by Ghironi and Melitz (2005) deserves particular attention. The authors provide an endogenous microfounded explanation for the B-S effect in response to aggregate productivity shocks. In their two-country DSGE model monopolistically competitive firms differ in productivity, and face sunk entry cost, fixed export costs and per-unit export costs. This suggests that only sufficiently productive firms enter the foreign market. Aggregate productivity shocks, changes in trade policies and market regulation affect the entry and exit decisions of firms. These in turn generate persistent deviations from PPP, even in the presence of flexible prices. Basically all goods are allowed to be traded; however, firms' decisions determine that some of the goods will remain nontraded in the equilibrium, since less productive firms do not find it profitable to export them. This is the feature of endogenous nontradedness, which can evolve over time. The final outcome of the model is consistent with the traditional B-S effect, that is, more productive countries are associated with higher average prices and with appreciating real exchange rates. This kind of endogenous nontradedness stemming from differential productivity of heterogeneous firms I would like to utilize in the third chapter of my proposed research, where I would correspondingly modify the basic DSGE model of a small open economy presented in this second chapter.

2.3 Basic model

The baseline model is built in the spirit of Natalucci and Ravenna (2005), Leith and Wren-Lewis (2006), Gali and Monacelli (2005), or Obstfeld and Rogoff (2000). The model incorporates several important features which are peculiar to CEE countries. In particular, the model can address the following stylized facts: production can take place in traded and nontraded goods sector, large share of imports are intermediate inputs, investment activity comes from abroad, and productivity growth differs in both production sectors. Let us describe the model and its underlying assumptions in detail.

The domestic economy is populated by infinitely-lived households. The households provide perfectly mobile labor services allocated between traded and nontraded sectors. On the other hand, the households own sector-specific capital, e.g. is immobile across sectors. Tradable good (H) is produced using labor (L^H), sector-specific capital (K^H) and imported intermediate input (X_M). Nontradable good (N) requires labor (L^N) and sector-specific capital (K^N) as inputs. Sector-specific investment goods (I^H, I^N) are obtained through combination of tradable goods, imported foreign goods (F) and nontradable goods. Since investment goods combine tradable, foreign and nontradable goods then foreign goods implicitly enter nontraded production as well through capital accumulation. In both production sectors we assume nominal price-stickiness in the fashion of Calvo (1983). In order to study the implications

of the Balassa-Samuelson effect we built in the model permanent sector-specific productivity shocks that would match patterns observed in data for CEE economies.

2.3.1 Consumption, investment, and price indices

The households consume aggregates of nontradable ($C_{N,t}$) and tradable ($C_{T,t}$) goods:

$$C_t = \left[(\gamma_{cn})^{\frac{1}{\rho_{cn}}} (C_{N,t})^{\frac{\rho_{cn}-1}{\rho_{cn}}} + (1-\gamma_{cn})^{\frac{1}{\rho_{cn}}} (C_{T,t})^{\frac{\rho_{cn}-1}{\rho_{cn}}} \right]^{\frac{\rho_{cn}}{\rho_{cn}-1}} \tag{5}$$

where $0 \leq \gamma_{cn} \leq 1$ is the share of nontradables and ρ_{cn} is the intratemporal elasticity of substitution between tradable and nontradable goods. The tradable consumption good comprises of home ($C_{H,t}$) and foreign tradable ($C_{F,t}$) goods:

$$C_{T,t} = \left[(\gamma_{ch})^{\frac{1}{\rho_{ch}}} (C_{H,t})^{\frac{\rho_{ch}-1}{\rho_{ch}}} + (1-\gamma_{ch})^{\frac{1}{\rho_{ch}}} (C_{F,t})^{\frac{\rho_{ch}-1}{\rho_{ch}}} \right]^{\frac{\rho_{ch}}{\rho_{ch}-1}} \tag{6}$$

where $0 \leq \gamma_{ch} \leq 1$ is the share of domestic tradable goods and ρ_{cn} is the intratemporal elasticity of substitution between home and foreign goods. The nontradable consumption good is an aggregate over a continuum of differentiated goods:

$$C_{N,t} = \left[\int_0^1 (C_{N,t})^{\frac{(\varsigma-1)}{\varsigma}} (z) dz \right]^{\frac{\varsigma}{\varsigma-1}} \tag{7}$$

where $\varsigma > 1$. The composite good price indices can be written as:

$$P_t^c = \left[(\gamma_{cn}) (P_{N,t})^{1-\rho_{cn}} + (1-\gamma_{cn}) \left(P_{T,t}^c \right)^{1-\rho_{cn}} \right]^{\frac{1}{1-\rho_{cn}}}$$

$$P_{T,t}^c = \left[(\gamma_{ch}) (P_{H,t})^{1-\rho_{ch}} + (1-\gamma_{ch}) (P_{F,t})^{1-\rho_{ch}} \right]^{\frac{1}{1-\rho_{ch}}}$$

$$P_{N,t} = \left[\int_0^1 (P_{N,t})^{1-\varsigma} (z) dz \right]^{\frac{1}{1-\varsigma}}$$

where P_t^c, $P_{T,t}^c$, and $P_{N,t}$ are the consumer price index, the price index for tradable consumption goods, and the price index for nontradable consumption goods.

Investments in the nontradable and domestic tradable sector are defined in a similar fashion. In addition, we allow elasticities to differ from those of the consumption composites[14]:

$$I_t^J = \left[(\gamma_{in})^{\frac{1}{\rho_{in}}} \left(I_{N,t}^J \right)^{\frac{\rho_{in}-1}{\rho_{in}}} + (1-\gamma_{in})^{\frac{1}{\rho_{in}}} \left(I_{T,t}^J \right)^{\frac{\rho_{in}-1}{\rho_{in}}} \right]^{\frac{\rho_{in}}{\rho_{in}-1}} \tag{8}$$

$$I_{T,t}^J = \left[(\gamma_{ih})^{\frac{1}{\rho_{ih}}} \left(I_{H,t}^J \right)^{\frac{\rho_{ih}-1}{\rho_{ih}}} + (1-\gamma_{ih})^{\frac{1}{\rho_{ih}}} \left(I_{F,t}^J \right)^{\frac{\rho_{ih}-1}{\rho_{ih}}} \right]^{\frac{\rho_{ih}}{\rho_{ih}-1}} \tag{9}$$

$$I_{N,t}^J = \left[\int_0^1 (I_{N,t}^J)^{\frac{\varsigma}{\varsigma-1}}(z)dz \right]^{\frac{\varsigma}{\varsigma-1}}, J = N, H \tag{10}$$

Investment price indices can be similarly expressed as:

$$P_t^i = \left[(\gamma_{in}) \left(P_{N,t} \right)^{1-\rho_{in}} + (1-\gamma_{in}) \left(P_{T,t}^i \right)^{1-\rho_{in}} \right]^{\frac{1}{1-\rho_{in}}}$$

$$P_{T,t}^i = \left[(\gamma_{ih}) \left(P_{H,t} \right)^{1-\rho_{ih}} + (1-\gamma_{ih}) \left(P_{F,t} \right)^{1-\rho_{ih}} \right]^{\frac{1}{1-\rho_{ih}}}$$

2.3.2 Households

The representative household has the following preferences:

$$U = E_t \sum_{i=o}^{\infty} \beta^i \left[\log C_{t+i} - l \frac{(L_{t+i}^s)^{1+\eta_H}}{1+\eta_H} + \chi_m \frac{(M_{t+i}/P_{t+i}^c)^{1-1/\zeta}}{1-1/\zeta} \right] \tag{11}$$

where L_t^s is the labor supply,

$$L_t^s = L_t^N + L_t^H, \tag{12}$$

η_H is the inverse of the labor supply elasticity, M_t/P_t^c are real money balances, and ζ is the elasticity of real money balances. We are assuming perfect substitution between hours worked in nontradable (L_t^N) and tradable (L_t^H) sectors.

Let W_t^N, W_t^H denote the nominal wage in the nontradable and tradable sector, e_t the nominal exchange rate; B_t, B_t^* holdings of discount bounds denominated in domestic and foreign

[14] The superscript J refers to the nontradable and tradable sector.

currency, v_t, v_t^* their corresponding price; R_t^N, R_t^H the real return to capital that is rented in tradable and nontradable sector, Π_t nominal profits from the ownership of monopolistically competitive firms, and T_t nominal government lump-sum taxes. Then, the household's budget constraint is given by:

$$\begin{aligned} &P_t^c C_t + B_t v_t + e_t B_t^* v_t^* + P_t^i I_t^N + P_t^i I_t^H + M_t = W_t^H L_t^H + W_t^N L_t^N + \\ &+ B_{t-1} + e_t B_{t-1}^* + M_{t-1} + P_{N,t} R_t^N K_{t-1}^N + P_{H,t} R_t^H K_{t-1}^H + \Pi_t - T_t \end{aligned} \tag{13}$$

The households receive income from supplying labor and renting capital to firms, from holdings of money, from interests on bonds, and from firms' profits. Income is used to purchase consumption and investment goods, to save in bonds, or to carry money into the next period.

The household maximize the intertemporal utility function (11) subject to (8)-(10), (12), (13) and the law of accumulation of the capital stocks:

$$K_t^J = \Phi\left(\frac{I_t^J}{K_{t-1}^J}\right) K_{t-1}^J + (1-\delta) K_{t-1}^J, J = N, H \tag{14}$$

Capital is assumed to be immobile across sectors. Capital accumulation incurs adjustment costs, with $\Phi'(.) > 0$ and $\Phi''(.) < 0$.

2.3.3 Firms

Nontradable sector. Nontradable goods are produced by a continuum of monopolistically competitive firms owned by households, and are subject to Calvo-type pricing mechanism. Each period a fraction of 1-θ_N of firms set prices optimally, while θ_N firms adjust prices to the steady state inflation rate π. Each firm $z \in [0,1]$ in nontradable sector maximizes discounted intertemporal profits subject to a demand curve. Demand for a nontradable product is derived both from domestic consumption $C_{N,t}$ and government expenditure $G_{N,t}$. Firms in nontradable sector use labor and capital inputs in order to produce. The production function has C-D form:

$$Y_{N,t}(z) = A_t^N \left[K_{t-1}^N(z)\right]^{\alpha_n} \left[L_t^N(z)\right]^{1-\alpha_n}$$

where $A_t^N$is an exogenous productivity parameter.

Those firms that are able to reoptimize their price in period T maximize

$$E_T\left[\sum_{t=T}^{\infty} \theta_N^{t-T} Q_{T,t} Y_{N,t}(z)\left[P_{N,T}(z)\pi^{t-T} - P_{N,t} MC_{N,t}(z)\right]\right]$$

subject to corresponding demand function; where $Q_{T,t}$ is households' stochastic discount factor, θ_N^{t-T} is the probability that the specific firm in nontradable sector will not be allowed to adjust its price between periods T and t, and $MC_{N,t}(z)$ is the real marginal cost. Aggregation over firms and log-linear approximation would result in forward-looking price adjustment equation for nontradable good inflation.

Tradable sector. If PPP is validated in the first chapter, we will assume perfectly competition in tradable sector, so the law of one price holds:

$$P_{H,t} = e_t P^*_{H,t}$$

However, if PPP is not validated, we would assume that firms in tradable sector are also monopolistically competitive and operate under Calvo-type pricing mechanism with a fraction of 1-θ_H of firms setting prices optimally, whereas θ_H firms adjusting prices to the steady state inflation rate π. Firms in tradable sector combine an imported intermediate good ($X_{M,t}$) and domestic value added ($V_{H,t}$) with the following CES production function:

$$Y_{H,t} = \left[(\gamma_v)^{\frac{1}{\rho_v}} (V_{H,t})^{\frac{\rho_v - 1}{\rho_v}} + (1-\gamma_v)^{\frac{1}{\rho_v}} (X_{M,t})^{\frac{\rho_v - 1}{\rho_v}} \right]^{\frac{\rho_v}{\rho_v - 1}}$$

Domestic value added is produced with labor and tradable capital:

$$V_{H,t} = A_t^H \left[K_{t-1}^H \right]^{\alpha_h} \left[L_t^H \right]^{1-\alpha_h}$$

where A_t^H is an exogenous productivity parameter.

Adopting Masten and Coricelli (2005) the log of exogenous productivity parameter is assumed to follow a AR(2) process with a unit root and a positive drift term:

$$a_t^J = \ln A + \left(1 + \gamma_n^J\right) a_{t-1}^J - \gamma_n^J a_{t-2}^J + \varepsilon_{t+1}^J, J = N, H$$

where $\varepsilon_{t+1}^J$is a zero mean i.i.d. productivity shock and $0 \leq \gamma_n^J < 1$. This specification allows for the simulation of permanent productivity increases in both sectors. In other words, a permanent productivity shock at time t continues to increase the level of productivity also in future periods.

2.3.4 Foreign sector

Depending on the result of the first chapter we can consider two different setup specifications, labeled as A and B.

Specification A. If PPP is validated for emerging countries in the first chapter of my dissertation, we will assume that the law of one price holds for foreign goods (F) and intermediate imported goods (M), e.g.:

$$P_{F,t} = e_t P^*_{F,t}$$

$$P_{M,t} = e_t P^*_{M,t}$$

where $P^*_{F,t}$ and $P^*_{M,t}$ follow exogenous stochastic processes.

Specification B. If PPP is rejected, following Monacelli (2005) we will introduce endogenous deviations from PPP due to the existence of monopolistically competitive importers. In this setup, domestic consumers are supposed to purchase foreign produced goods from importers that exert market power. Importers purchase foreign goods at world prices, so the law of one price holds at the border. However, charging a mark-up over cost importers create a wedge between domestic prices and import prices of foreign goods stated in the same currency. Thus, the law of one price does not hold for foreign goods; e.g. we can define so called the law of one price gap as:

$$\psi_{F,t} = \frac{e_t P^*_{F,t}}{P_{F,t}}$$

Notice that if PPP holds then $\psi_{F,t} = 1$. So, we will assume in this specification that pass-through from exchange rate movements to the domestic currency prices of imports is imperfect[15].

Again, we will assume Calvo-type mechanism for domestic importers, with 1-θ_F importers setting prices optimally each period. Importers maximize the discounted stream of expected profits

$$E_T \left[\sum_{t=T}^{\infty} \theta_F^{t-T} Q_{T,t} C_{F,t}(z) \left[P_{F,T}(z) \pi^{t-T} - e_t P^*_{F,t}(z) \right] \right]$$

subject to corresponding demand function. Note that the marginal cost of purchasing imports is the law of one price gap for the particular good. Aggregation over importers would result in a Phillips curve relationship between imported price inflation and the law of one price gap.

[15] Alternative extreme specifications, such as producer currency pricing in Obstfeld and Rogoff (1995), and local currency pricing in, among others, papers by Betts and Devereux (2000), Benigno (2004), Chari, Kehoe, and McGrattan (2002) are widely used in the NOEM literature. Nonetheless, Campa and Goldberg (2001) reject both extreme assumptions since empirical evidence from 25 OECD countries suggests only partial pass-through in the short-run.

The effective terms of trade are given by:

$$S_{F,t} = \frac{P_{F,t}}{P_{H,t}}$$

The internal price ratio, or also called internal exchange rate is defined as:

$$q_t = \frac{P_{H,t}}{P_{N,t}}$$

The CPI-based real exchange rate is given by:

$$Q_t = \frac{e_t P_t^*}{P_t^c}$$

Furthermore, as in Schmitt-Grobe and Uribe (2001), households can borrow from abroad at the nominal interest rate which is given by the exogenous world interest rate plus a risk premium which is increasing in the real value of foreign debt:

$$(1 + i_t^*) = \left(1 + \tilde{i}_t^*\right) g\left(-\frac{e_t B_t^*}{P_{H,t}}\right)$$

where g(.)>0 and g'(.)>0. This should ensure the stationarity of the model.

2.3.5 Government

The government finance spending in tradable and nontradable goods by lump-sum taxes and money creation:

$$P_{H,t} G_{H,t} + P_{N,t} G_{N,t} = M_t - M_{t-1} + T_t$$

Government budget constraint is required to be in balance each period.

2.3.6 Market clearing

Nontradable and tradable sector resource constraints are as follows:

$$Y_{N,t} = C_{N,t} + I_{N,t}^N + I_{N,t}^H + G_{N,t}$$

$$Y_{H,t} = C_{N,t} + C_{H,t}^* + I_{H,t}^N + I_{H,t}^H + G_{H,t}$$

where $C^*_{H,t}$ are net exports of domestic tradable good.

The trade balance in units of domestic tradable good is given by:

$$NX_{H,t} = C^*_{H,t} - \frac{P_{F,t}}{P_{H,t}}\left(C_{F,t} + I^N_{F,t} + I^H_{F,t}\right) - \frac{P_{M,t}}{P_{H,t}}X_{M,t}$$

Nominal current account is defined by:

$$e_t B^*_t = (1 + i^*_{t-1})\, e_t B^*_{t-1} + P_{H,t} NX_{H,t}$$

with the assumption of zero net supply of domestic bonds.

Labor market clearing condition:

$$L^d_t = L^N_t + L^H_t = L^s_t$$

2.4 Solution, research methodology and data

Due to the sufficient complexity of the proposed model it is likely that derivation of exact analytical solution would not be possible. Thus, we would follow the usual strategy to approximate the solution in the neighborhood of the steady state. We do so by log-linearizing the equilibrium conditions. The resulting linear dynamic system would be solved with the help of the DYNARE toolbox.

In addition, we would derive central bank's loss function. This would be done by taking a second-order approximation to the utility function of the representative household. Then we would try to collapse central bank's objective function into quadratic terms that would involve inflation gap, output gap, and perhaps additional terms such as terms of trade gap or the exchange rate gap. Afterwards we can compare the welfare losses in the case when a central bank follows alternative suboptimal monetary policy rules.

Since our main interest is to assess the implications of the B-S effect on the ability of emerging countries to satisfy the Maastricht criteria we would also investigate impulse response functions to the B-S productivity shock. This allows us to investigate possible compliance with the inflation criterion. Following Natalucci and Ravenna (2005) we can analyze the inflation/exchange rate variance trade-offs under alternative monetary policy rules in order to determine whether fulfilling both ERM II and the inflation criterion is possible. Finally, we would check the robustness of the results to changes in the model parameters.

The model will be calibrated for the case of the Czech Republic. This particular choice is not random because we would like to compare our results with the studies by Laxton and

Pesenti (2003), Masten and Coricelli (2005), and Natalucci and Ravenna (2005); all of them calibrate their DSGE models to the Czech Republic. The required data would be drawn from the databases of International Monetary Statistics and Source OECD provided by IMF and OECD, which are freely accessible in CERGE-EI Library.

2.5 Possible extensions of the model

The model presented in this chapter can be extended in several directions:

- A more comprehensive model should probably take into account some additional sources of nominal rigidities, such as sticky nominal wages. This can be done in the fashion of the paper by Erceg, Henderson and Levin (2000), where each household is a monopoly supplier of a differentiated labor service to the production sector. Thus, the households are able to set their own nominal wages in staggered contracts à la Calvo.

- When there is a role for importing firms (Specification B of the foreign sector) we may introduce separate production function for importers as well. For example, we would require combination of labor input and foreign good into the final good that can be sold at the domestic market. By doing this all imported goods would be treated as intermediate goods. This represents a mechanism which is advocated, for instance, by Allsopp, Kara and Nelson (2006) or McCallum and Nelson (1999).

- The most ambitious would be to introduce endogenous nontradedness into the model in the spirit of Ghironi and Melitz (2005). That is, make firms to differ in productivity level, which in turn, would influence their entry and exit decisions in both domestic and foreign markets. The set of traded and nontraded goods can evolve over time as a consequence of varying number of differently productive firms in the economy. This extension I would like to elaborate in the third chapter.

3 Introducing endogenous Balassa-Samuelson effect into a small open economy

3.1 Motivation and sketch of the idea

The conventional B-S effect is built on several implausible assumptions. First of all, it relies on exogenously defined nontraded sector. This is quite problematic when we look closely at the data. The micro-level data studies suggest that the division between traded and nontraded sectors evolves over time due to the reason that firms can often change their export status (Bernard and Jensen, 2004). Furthermore, many goods in the tradable sector are simply not traded which make the exact division between traded and nontraded sector even more complicated. Second potential failure of classical B-S effect might arise because of the assumption that the law of one price holds for traded goods. There is a lot of reasons and empirical evidence why this may not be the case. The law of one price for tradable goods may not hold since many prices of tradable goods involve nontradable components (rents, distribution services, advertising, and the like). Additionally, the law of one price may not hold since there might be nominal price rigidities in the tradable sector or the pass-through from exchange rate movements to the domestic prices is imperfect. Empirically, among others, Engel (1999) documented cross-country price differences for tradable goods.

These potential problems of the conventional B-S effect are elegantly solved in the recent paper by Ghironi and Melitz (2005). The authors build a two-country DSGE model with heterogeneous firms which differ in their productivity level. In addition, these monopolistically competitive firms face sunk entry cost, fixed export costs and per-unit export costs, so only sufficiently productive firms enter the foreign market. All goods are allowed to be traded but some firms, the less productive ones, do not find it profitable to export. Thus, firms' decisions cause that some goods remain nontraded in the equilibrium. Aggregate productivity shocks, changes in trade policies and market regulation influence the entry and exit decisions of firms as well. Hence, the set of traded and nontraded goods in the economy can substantially evolve over time; and this is the feature of so called endogenous nontradedness. Furthermore, even under fully flexible prices the model is able to generate persistent deviations from PPP, which would be absent if firms could not differ in their productivity levels. The final outcome of the model is consistent with the traditional B-S effect, that is, more productive countries are associated with higher average prices and with appreciating real exchange rates. But there is the difference that the productivity shock hits the whole economy in this model, whereas in the conventional B-S effect only traded sector is affected.

Understanding the advantages of the above described endogenous microfounded B-S effect I would like to incorporate it into the basic DSGE model of a small open economy presented in the second chapter. Basically, we would additionally introduce heterogeneous firms that

differ in the productivity level. Extending the model in this direction, however, brings into light many potential difficulties. So far, I am not sure whether it is possible to migrate from a two-country setup into a small open economy framework with this particular extension. Moreover, Ghironi and Melitz (2005) showed that their model generates substantial persistent deviations from PPP in a world of flexible prices. Specifically, less than half of the long-run exchange rate appreciation occurs within five years in response to permanent productivity increase. Intuitively, adding nominal rigidities into the model would likely increase persistent deviations from PPP further beyond; perhaps beyond the plausible values observed in the data. Therefore, we would be forced to relax some assumptions either in our model or either to adapt the assumptions from Ghironi and Melitz (2005) in a different way.

Despite of the possible problems, the idea to introduce endogenous B-S effect into a small open economy framework is challenging in the sense that the current strand of literature still misses a closer link between new open economy macroeconomic models and trade theory, which relies more on microeconomic foundations.

3.2 Related literature

The concept of endogenous nontradedness is not a completely new thing to the economic literature. Already Dornbusch, Fischer, and Samuelson (1977) investigated the endogenous determination of nontraded sectors. They found that aggregate productivity shocks can affect price differentials across countries. Bergin and Glick (2003) figured out that endogenous nontradedness can also reside in differences in trade costs between sectors. Furthermore, Obstfeld and Rogoff (2001) argue that inclusion of per-unit trade costs into the models can help explain endogenous nature of tradedness, thus resolving a number of international macroeconomics puzzles. Firm's entry decisions and endogenous nontradedness are studied, for example, by Bergin, Glick and Taylor (2003). These authors analyze the B-S effect in the model with monopolistic competition, fixed export costs, and heterogenous productivity, but where the number of producers is exogenously specified.

4 Tentative time plan

	Chapter #1	Chapter #2	Chapter #3
Mar 2007	Test development		
Jun 2007	Results, first draft	Model construction	
Sep 2007	Final draft	Model solution, data collection	
Dec 2007		Results, first draft	Model construction
Mar 2008		Final draft	Model solution, data collection
Jun 2008			Results, first draft
Sep 2008			Final draft
Fall 2008	Dissertation Defense		

5 Proposed dissertation committee

- Michal Kejak - CERGE-EI (chair)
- Evžen Kočenda - CERGE-EI (confirmed)
- Sergey Slobodyan - CERGE-EI
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