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Essays on Exporting Behavior of Firms and on Inflation Persistence

Dissertation

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CERGE
Center for Economic Research and Graduate Education
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The thesis contains three essays on the exporting behavior of firms and on the persistence of inflation.

In the first two essays, I examine the behavior of exporters and non-exporters using a rich firm-level panel data source from the Czech Republic. The first essay reacts to recent literature on learning-by-exporting and explores whether exporting firms are more productive because initially more productive firms self-select themselves into exporting or because exporting firms are becoming more productive. To provide convincing estimates, one must be able to disentangle learning-by-exporting from changes in company management that induce the company to both start exporting and introduce productivity increasing measures. Therefore, I compare estimates based on matching on propensity score, which do not control for potential management changes, to estimates based on an instrumental variables strategy. Specifically, I focus on firms that start exporting due to changes in the industry-specific ratio of producer prices on domestic and foreign markets. The results suggest that learning-by-exporting in the Czech Republic is not significant, either statistically or economically, irrespective of the method used.

In the second essay, I estimate the role of sunk costs connected with entry into foreign markets. Results suggest that costs are significant but not different for firms with domestic and foreign owners. In addition, I find that exporters with foreign owners are twice less responsive to exchange rate changes than exporters with domestic owners, but more responsive to changes in the volatility of exchange rates. This analysis shows to what extent exchange rate management is meaningful in small open economies and how growing shares of foreign-owned firms changes the responsiveness of foreign trade to exchange rates movements.

Finally, in the third essay, coauthored with Michal Franta and Kateřina Šmídková, we study how the choice of estimation method influences the comparison of inflation persistence estimates between new EU member states and euro zone countries. We argue that persistence may not be as different between the two country groups as one might expect. It is shown that one should work carefully with the usual estimation methods when analyzing the new member states, given the scope of the convergence process they went through. Since differences in inflation persistence play a role in the debate on the timing of euro adoption, our results provide a new perspective on inflation persistence differentials.

♣ I would like to thank my dissertation committee, in particular committee chair Jan Hanousek for many useful discussions and suggestions. I am also grateful to referees Jan Kmenta and Jan Svejnar for their insightful comments.

Contents

Learning-by-Exporting or Managerial Quality?
Evidence from the Czech Republic

Branislav Saxa[1]

November 2008

Abstract

This paper employs firm-level panel data from the Czech Republic to investigate the empirical relevance of the learning-by-exporting hypothesis. To provide convincing estimates, one must be able to disentangle learning-by-exporting from changes in company management that induce the company to both start exporting and introduce productivity increasing measures. Therefore, I compare estimates that do not control for potential management changes to estimates based on an instrumental variables strategy. Specifically, I focus on firms that start exporting due to changes in the industry-specific exchange rate and industry-specific ratio of producer prices on domestic and foreign markets. The results suggest that different kinds of productivity enhancements can be attributed to learning-by-exporting on one side and managerial effects on the other side.

Keywords: exporting, productivity, matching on propensity score, local average treatment effect

JEL classification: D24, D83, F13, F14-15, C23

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1 Introduction

Exporters are more productive than non-exporters. Empirical evidence for this claim can be found in numerous recent studies,[1] though causality in the relationship is not that clear. There are two main non-exclusive theories which attempt to explain these findings. The first, often referred to as the self-selection theory, proposes that more productive firms self-select into exporting due to the existence of sunk costs connected with entering foreign markets[2] and possibly stronger competition on foreign markets. The second theory, referred to as the learning-by-exporting theory, suggests that exporting firms enhance their productivity through selling abroad. This can happen in several ways. Exporters can learn from foreign customers, they can increase productivity due to the pressure of international competition, or they can simply gain new markets and benefit from economies of scale. In terms of causality, there is a clear distinction between the two theories. According to the self-selection theory, causality indicates that higher productivity leads to exporting. On the contrary, the learning-by-exporting theory argues that exporting enhances productivity. To reiterate, these two theories are non-exclusive, i.e., more productive firms can self-select into exporting but, at the same time, the productivity of exporters can grow faster than the productivity of non-exporters.

The power of the second theory becomes clearer if the domestic economy is less developed and relatively small. For a less developed country, the greater difference in technology levels between domestic and foreign firms increases the possible productivity gains that exporting firms can achieve through contacts with more developed foreign partners. In other words, a firm in a less developed country has a greater potential to learn by exporting than does a firm in an advanced country. Further, a firm operating in a small country can substantially increase its sales by entering foreign markets. If such a firm can benefit from economies of scale, the second theory gains even stronger merit.

[1] See, for example, Bernard and Jensen (1999), Clerides, Lach and Tybout (1998), Bernard and Wagner (1998), Castellani (2001), Aw, Chung and Roberts (2000), Head and Ries (2003), Pavcnik (2002), and Arnold and Hussinger (2005).

[2] The existence of sunk costs was empirically confirmed in several studies starting with Roberts and Tybout (1997).

While empirical studies unanimously[3] confirm the first direction of causality, i.e., that more productive firms self-select themselves into exporting, empirical evidence on the second direction, i.e., learning-by-exporting, is ambiguous. Learning-by-exporting was rejected in the cases of the USA, Germany, Taiwan, Korea, Colombia, Mexico and Morocco; learning effects were found in China, some African countries, and to some extent Spain[4] and Italy.

The motivation for this paper is built on the expectation that exporters from transition countries in Central and Eastern Europe (CEE) could gain substantially in terms of productivity. One reason is the initial technological gap between domestic and foreign firms (mainly those from Western Europe, where a major part of exports were directed soon after the collapse of COMECON[5]) at the beginning of transition. The catch-up process generally implies strong growth in productivity. In the presence of heavy productivity gains in general, the difference in productivity gains between exporting and non-exporting firms could be more pronounced. Therefore, if learning-by-exporting exists, it should be more significant in transition countries than in countries with benign productivity growth.

Besides searching for evidence of learning-by-exporting in a similar way as previous studies did using firm-level data in other countries, I also address the following: Does simultaneous occurrence of the beginning of exporting and productivity gains confirm the validity of the learning-by-exporting theory or can it be a consequence of other factors, e.g., change in management? In a typical situation, a new manager takes charge of a non-exporting manufacturing firm. The fact that the firm did not export before the new manager takes control does not have to be necessarily related to the productivity of the firm. The firm could have not exported its products because the previous manager had no experience with exporting in general or because the manager was not willing to undergo the risk of entering foreign markets. On the contrary, the new manager might have past experience with exporting and can recognize the firm's exporting potential or might be less risk averse and eager to start

[3] To my knowledge, no paper investigating the hypothesis that firms self-select into exporting rejects that hypothesis.
[4] Delgado, Farinas and Ruano (2002) do not find significant learning effects for the whole sample, but only for a sub-sample of young firms in Spain.
[5] Council for Mutual Economic Assistance was an economic organization of communist countries, mainly coordinating international trade between panned economies, 1949-1991.

with exporting. At the same time, the new manager can recognize opportunities to increase productivity and adopt measures to boost it. It might well be that these opportunities existed before, however, the previous manager did not identify them or simply preferred to maintain the status quo. As a result, two changes can be observed in a firm-level data of the considered firm: export entry and productivity increase. In the described typical situation, both are the consequence of the new manager taking charge of the firm. Increased productivity does not have to be a necessary condition for entering foreign markets and, vice versa, observed productivity enhancements are not a result of exporting. However, researchers identifying an occurrence of both changes at the same time or with a lag are likely to argue in favor of the learning-by-exporting hypothesis. Since a change in management is typically not observable in firm-level data, it is not feasible to directly test the relevance of the described situation empirically. To disentangle learning-by-exporting from explained simultaneous changes in export and productivity induced by a new manager, I employ the movements of exchange rates and producer prices as exogenous factors that can motivate a firm to start to export.

In addition, controlling for ownership can have a serious impact on the empirical results of testing the learning-by-exporting hypothesis. The line of reasoning is as follows: If firms owned by a foreign owner have access to technology directly from the foreign owner, their potential to increase productivity through exporting is limited. On the other hand, exporting may form an important channel of productivity gains for domestic firms that do not have the possibility to acquire productivity-enhancing knowledge from a foreign owner. Therefore, pooling domestic and foreign-owned firms together can conceal the effect of learning-by-exporting.

This paper thus contributes to the existing literature in two ways. First, by testing the learning-by-exporting hypothesis on data from the Czech Republic, a representative of the CEE region. Due to the high growth of productivity over the transition period and the importance of exports reflected in very high trade openness,[6] the CEE region is unique among those economies for which similar research is available. Second, the study suggests an approach that is focused on firms that start to export due to

[6] Openness of the Czech economy, defined as (Export + Import)/GDP, reached 110% in 2000, placing the Czech Republic among the most open economies in Europe.

exogenous factors. Therefore, I am able to eliminate a case of a simultaneous rise of productivity and start of exporting due to the case of firm with new management, which launch exporting and apply measures, boosting productivity at the same time.

The remainder of the paper is organized as follows. Related literature and available empirical results are described in the next section. The methodology is outlined in section three. The fourth section describes the data, and the results are discussed in the fifth section. Section six deals with robustness issues and section seven concludes.

2 Literature Review

While most empirical studies support the self-selection theory, limited evidence exists that validates the learning-by-exporting theory. One pioneering paper is that of Clerides, Lach and Tybout (1998), who employ firm-level data from Colombia, Mexico and Morocco and confirm the self-selection theory, but find little support for the learning-by-exporting theory.[7] The significance of self-selection but lack of evidence for learning-by-exporting is confirmed by Bernard and Jensen (1999) for U.S. firms and by Arnold and Hussinger (2004) for German firms. Isgut (2001) shows that exporters are larger, have higher labor productivity, and pay higher wages three years before entering foreign markets but that labor productivity doesn't grow faster in exporting firms after they start exporting. Delgado, Farinas and Ruano (2002) find evidence supporting self-selection in Spanish data and some support for learning-by-exporting, albeit limited to young exporters.

Results consistent with the learning-by-exporting theory can be found in Girma, Greenway and Kneller (2002) for U.K. firms, or in the study of firms from four African countries performed by Bigsten et al. (2004). Castellani (2002) in his study employing data on Italian firms finds that exporting status itself has no effect on productivity but that productivity growth is positively related to export intensity. Focusing on labor productivity only, Wagner (2002) uses German firms to show that exporting has positive effects on labor productivity growth. Finally, Bleaney, Filatotchev and Wakelin (2000) test the learning-by-exporting hypothesis for Belarus,

[7] Some learning was found in the case of Morocco.

Russia and Ukraine, and yield results in support of the learning-by-exporting theory. However, caution is called for here since the authors use the number of employees as the only measure of productivity. Moreover, the used sample is rather small ("roughly 75 from each of the three countries") and likely not representative.

In addition to the self-selection and learning-by-exporting theories, Hallward-Driemeier, Iarossi and Sokoloff (2002) propose an alternative explanation for a correlation between export and productivity. They argue that firms entering foreign markets do not show higher productivity due to an exogenous productivity shock, but rather as a result of their past decision to enter foreign markets and subsequent decisions aimed at increasing productivity. The authors use survey data from five Asian countries to assess the appropriateness of their theory. Comparing information on firms already exporting in the first year of their existence with firms that start exporting only later, the authors find support for their view. Based on their results, they argue that expansion of export opportunities in less developed countries could increase the incentives of firms to export, and consequently to increase their productivity.

Different results from different studies do not necessarily have to be attributed to country specifics only. In terms of methodology, the studies mentioned above employ a variety of approaches. Two main features can influence the results of causality described above: the method used to measure productivity and the estimation strategy. As for measuring productivity, measures of total factor productivity (TFP) based on different production functions are employed in several cases (e.g., Bigsten et al. (2004) use TFP based on Translog and Cobb-Douglas production functions; Girma, Greenaway and Kneller (2004) use TFP based on Cobb-Douglas production function). Arnold and Hussinger (2004) use the Olley and Pakes (1996) two-step semi-parametric procedure to control for the simultaneity problem in TFP estimation. Clerides, Lach and Tybout (1998) proxy productivity by average variable costs and labor productivity. Finally, as mentioned earlier, Bleaney, Filatotchev and Wakelin (2000) use employment as the only measure of performance, due to the impossibility of using monetary measures stemming from the presence of high inflation.

Estimation strategies differ from paper to paper as well. Clerides, Lach and Tybout (1998) use panel data to estimate a system of two equations – one for participation in export markets and one for the process governing their productivity measure. Consequently, they use GMM to estimate the system and test both self-selection and learning-by-exporting hypotheses. Bigsten et al. (2004) use maximum likelihood as well as GMM estimation in a setup similar to the one of Clerides, Lach and Tybout (1998). Due to the lack of available time series, Castellani (2002) opts for a cross-section estimation of two separate equations for export participation and TFP growth. In addition to export participation, Castellani (2002) proposes a model with an export intensity equation, estimated by tobit due to values censored both from left and right (at 0 and 1). Girma, Greenway and Kneller (2004) as well as Wagner (2002) use a matching approach to test for direction of causality. Further, Arnold and Hussinger (2004) exploit both the matching approach and the concept of Granger causality. Finally, Delgado, Farinas and Ruano (2002) use non-parametric tests to test the self-selection and learning-by-exporting hypotheses.

3 Methodology

My main objective is to estimate the effects of export entry on a firm's productivity. In this section, the estimation of productivity measures is described first. Consequently, two approaches adopted in the estimation of the effect of export entry on productivity are explained: matching on propensity score and regression analysis. While matching on propensity score is more robust to model misspecification, regression analysis is used for comparison. With both estimation techniques, a setup without instrumental variables is estimated first. Subsequently, the instrumental variable setting enables me to estimate the effect of export entry on the productivity of these firms that entered foreign markets due to an exogenous impetus.

3.1 Productivity Measures

Three productivity measures are employed to evaluate productivity developments at the firm level: labor productivity based on output, labor productivity based on value added and total factor productivity utilizing a methodology suggested by Levinsohn and Petrin (2000).[8] In addition, each productivity measure is used in the level as well as in the growth rate version. Therefore, I effectively compare six productivity indicators.

Labor productivity based on output is defined as output divided by labor (see Table 1 for the definitions of underlying variables). Labor productivity based on value added is defined as value added divided by labor. Total factor productivity is defined as the residual from the Cobb-Douglas production function. Compared to labor productivity, total factor productivity has an advantage of taking into account additional inputs, not only labor. However, it has its drawbacks, too. One of them is the reliability of data on capital stock, which is particularly disturbing in the firm-level data statistics of transition countries. The other problem is the residual nature of total factor productivity measurement and its problematical interpretation. Due to the different nature of labor productivity and total productivity measures, it is not possible to compare the results based on these two approaches directly. To address the simultaneity problem in the input choice, I use the approach suggested by Levinsohn and Petrin (2000) to measure total factor productivity.[9]Simultaneity problem stems from the fact that at least part of the firm's productivity can be observed by the management before the decision about factor inputs is taken. But then the error term of the productivity estimation equation is correlated with the inputs, i.e., explanatory variables. This leads to an estimation bias. Levinsohn and Petrin (2000) suggest a methodology that employs the data on intermediate inputs that addresses the problem of simultaneity.[10]

The productivity of export starters and non-exporters is compared in terms of levels and growth rates. In the level version, the productivity of each firm in each year is recomputed vis-à-vis the average productivity in the group of firms from the same 2-

[8] I am primarily looking at differences in the production function here. Alternatively, one can also investigate differences in productivity due to differences in utilization of inputs, e.g., by looking at marginal productivities of labor and capital.

[9] Total factor productivity estimation is implemented in STATA using the *levpet* procedure suggested by Petrin, Poi and Levinsohn (2004). The revenue version was used with materials as a proxy variable. Revenues, capital stock and materials were deflated using industry specific producer price indexes. Logarithms of all variables were used in the estimation.

[10] A Cobb-Douglas production function model with stochastic profits due to disturbance not known before the input decision is made is introduced in a seminal paper of Zellner, Kmenta and Dreze (1966).

digit industry, same size group[11] and same year, where the average productivity is set to 100. The whole population of firms is used in the group comparison (not only export starters and non-exporters). It is important to note that although such an approach makes productivity more comparable across firms, the productivity time series for a single firm becomes inconsistent. Productivity growth rates are year-on-year growth rates of original productivity levels without within group comparison.

3.2 Matching on Propensity Score

Matching on propensity score is not a new approach in the literature on learning-by-exporting (see Wagner 2001, Girma, Greenaway and Kneller 2004, Arnold and Hussinger 2005). The idea is to match two otherwise similar firms with one difference – one of the firms starts with exporting, the other remains on the domestic market only. The two firms have to be matched in the year preceding the year when the exporter begins exporting. The outcome of interest, in this case the productivity measure, is then compared between the groups of export starters and non-exporting firms.

Matching on propensity score is implemented using the Stata command *psmatch2*, described in detail in Leuven and Sianesi (2003). I opt for one-on-one matching with common support[12] and logit function used for estimation. Matching is based on the probability of firms starting to export given the covariates. The choice of covariates is motivated by two goals. First, covariates should well predict the exporting status of a firm. For this reason, I consider variables that appear as significant explanatory variables in the previous research on exporting behavior. Second, as Caliendo and Kopeinig (2008) note, using a large set of covariates might lead to high variance of estimated effects; therefore, I tend toward a more parsimonious set of covariates. In the first setup, labor, investments and revenues are included, i.e., variables that do not explain probability of exporting by exogenous changes. In the second setup, the set of three covariates from the first setup is augmented with industry-specific exchange

[11] Firms are divided into four size groups based on the number of employees recomputed on an eight hour day basis.
[12] Common support means that treatment observations whose propensity score is higher than the maximum or less than the minimum propensity score of the controls are dropped. Opting for common support leads to omission of some observations in the estimation.

rates and industry-specific ratio of producer prices representing exogenous changes. Thus, in the first case I compare the productivity between non-exporters and export starters matched using firm characteristics only. In the second case, productivity is again compared between non-exporters and export starters, however, with an additional condition requiring that matched firms are similar not only in endogenous firm characteristics, but they also face a similar exogenous shock. Therefore, comparing the results estimated using the first and the second setup enables me to disentangle the productivity enhancing effects of exporting due to exogenous shock from productivity enhancing effects of other types including managerial shocks.

3.3 Regression Analysis and Local Average Treatment Effect

In addition to estimating average treatment effect using matching on propensity score, regression analysis is employed. Specifications used for the estimation on the sample of non-exporters and export starters are described below. First, I estimate the effect of exporting on the *productivity* measure using a fixed effect estimator:

$$productivity_{i,t} = \beta_0 + \beta_1 firstyear_{i,t} + \beta_2 \ln l_{i,t-1} + \beta_3 \ln k_{i,t-1} + \delta controls_{i,t} + \alpha_i + \varepsilon_{it} \quad (1)$$

where $productivity_{i,t}$ is a selected productivity measure of the firm *i* in the year *t*, $firstyear_{i,t}$ is a dummy variable equal to 1 if the firm *i* exports in the year *t*, but does not export in the year *t-1*. Variables *l* and *k* denote labor and capital, and $controls_{i,t}$ include year dummies that are supposed to capture time-varying effects common for all firms. To avoid simultaneity issues stemming from the fact that some of the explanatory variables enter the productivity measurement in the first step, labor and capital enter the estimation equation (1) with the lag of one year. Finally, α_i is a firm fixed effect and ε_{it} is the error term. Firm fixed effects control for time-invariant productivity differences between firms. To capture the relationship between the productivity and export decision one year before and one year after starting to export, I also estimate (1) with a lag and lead on *firstyear*. Using the following two equations, I estimate the productivity differences between non-exporters and export starters one year before and one year after export entry.

$$productivity_{i,t} = \beta_0 + \beta_1 firstyear_{i,t+1} + \beta_2 \ln l_{i,t-1} + \beta_3 \ln k_{i,t-1} + \delta controls_{i,t} + \alpha_i + \varepsilon_{it} \quad (1a)$$

$$productivity_{i,t} = \beta_0 + \beta_1 firstyear_{i,t-1} + \beta_2 \ln l_{i,t-1} + \beta_3 \ln k_{i,t-1} + \delta controls_{i,t} + \alpha_i + \varepsilon_{it} \quad (1b)$$

Observing an increase of productivity before the export entry would be in line with the hypothesis suggesting that firms prepare themselves for exporting by increasing productivity as advocated by Hallward-Driemeier, Iarossi and Sokoloff (2002). On the other hand, observing productivity enhancements of export starters one year after export entry is consistent with the learning-by-exporting hypothesis. If an export starter has to incur sunk costs related to export entry in the year of entry, then one can observe an increase in productivity of such firm only in subsequent years.

Instruments are employed in the second specification. Dummy *firstyear* is instrumented using an industry specific exchange rate and industry specific ratio of producer prices in the Czech Republic and abroad, their lags and year-on-year differences.[13] By instrumenting the export entry indicator in the described way, I obtain the local average treatment effect of starting export for the firms that entered export markets due to changes in exchange rates or relative prices, i.e., due to clearly external factors.[14] Therefore, this estimate of learning-by-exporting disentangles productivity enhancements due to export entry induced by changes in relative prices and exchange rates and productivity enhancements of all other types, including the effect of a new manager as described in the introduction.[15]

Export intensity, defined as a ratio of export and output, varies substantially across firms and industries, as Figures 1 and 2 in the appendix illustrate. It is possible that only firms with relatively high export intensity benefit from learning-by-exporting. Therefore, the specifications alternative to (1, 1a, 1b) are estimated, where the

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[13] See chapter 4 for a detailed description of the construction of industry specific exchange rates and industry specific ratios of producer prices home and abroad.

[14] One potential problem with the employed instruments might be the fulfillment of the condition requiring orthogonality of instrument and the error term in the equation of interest. In some cases, it is not possible to exclude the possibility that exchange rates and foreign producer prices influence productivity of both exporters and non-exporters. See Deaton (2009) for a discussion on the issue of externality and exogeneity of instruments.

[15] Changes in relative prices and exchange rates can lead to management changes in certain cases too, however I expect the occurrence of such cases to be negligible compared to the occurrence of export entries due to changes in exchange rates.

explanatory variable indicating the exporting status of a firm reflects the firm's export intensity instead of the exporting dummy. More specifically, variable *firstyear_ei* is equal to zero for non-exporters, while it is equal to the company's export intensity in the case of an export starter.

$$productivity_{i,t} = \beta_0 + \beta_1 firstyear\_ei_{i,t} + \beta_2 \ln l_{i,t-1} + \beta_3 \ln k_{i,t-1} + \delta controls_{i,t} + \alpha_i + \varepsilon_{it} \quad (2)$$

$$productivity_{i,t} = \beta_0 + \beta_1 firstyear\_ei_{i,t+1} + \beta_2 \ln l_{i,t-1} + \beta_3 \ln k_{i,t-1} + \delta controls_{i,t} + \alpha_i + \varepsilon_{it} \quad (2a)$$

$$productivity_{i,t} = \beta_0 + \beta_1 firstyear\_ei_{i,t-1} + \beta_2 \ln l_{i,t-1} + \beta_3 \ln k_{i,t-1} + \delta controls_{i,t} + \alpha_i + \varepsilon_{it} \quad (2b)$$

As in the case of matching on propensity score, six productivity measures are used, i.e., levels and growth of labor productivity based on output, labor productivity based on value added and total factor productivity.

4 Data and Descriptive Statistics

Firm-level panel data are provided by the Czech Statistical Office. The sample of manufacturing firms covering the period 1997-2002 is employed. Firms that do not occur in the sample every year over the six-year period were eliminated. As a result, 86% of firms were excluded. Out of excluded firms, 27% of firms appeared in the sample only in the year 1997 and less than 7% appeared in the sample in years 1997 and 1998 only. Approximately 6% and 4% of excluded firms appear in the sample only in year 2002 and years 2001-2002, respectively. No other systematic pattern was recognized in the excluded firms. Also, due to the relatively small number of firms owned by municipalities, associations and cooperatives, those were eliminated as well. The industry of the firm is identified using its 3-digit NACE code, although I use the 2-digit NACE division in all cases except for the construction of industry specific exchange rates. Geographically, firms are divided into eight regions.

The ownership of a firm is defined as follows. If domestic private, domestic state or foreign owners control more than 50% of a firm, then the ownership indicator takes the value of private, state, or foreign, respectively.[16] If a firm is owned by domestic owners only, but no ownership type controls more than 50%, the ownership indicator takes the value of mixed. Finally, if foreign owners control not more than 50% of a firm, the ownership indicator is international. The baseline analysis employs only domestic private firms; the dataset of all firms is used in the robustness checks only. The reason is that foreign owned firms are likely to boost their productivity through knowledge and technology gained from the foreign owner rather then through learning-by-exporting. Numerous studies examine the effect of foreign owner on the performance and many find it positive and significant. The examples for the Czech Republic include Djankov and Hoekman (1999), Evenett and Voicu (2001) and Hanousek, Kocenda and Svejnar (2007). Not to mix these two effects, the learning-by-exporting hypothesis is tested separately on the set of domestically owned firms, and, on the set of firms with a foreign or international owner.

A firm is considered to be an exporter in a given year if the value of the firm's exports is greater than zero. Numbers of export starters as well as non-exporters in each industry and year are reported in Table A1 in the appendix. In order to eliminate false changes in export status that can emerge in the case of misreported value of exports, three alternative datasets are constructed. In the first dataset, firms that changed their export status for one year only (i.e., reported no export in one year while reported non-zero exports in both previous and following years or vice versa) are eliminated. In the remainder of the paper, this dataset is referred to as the baseline dataset. In the second dataset, all firms that changed their export status more than once over the sample period are eliminated. Finally, in the third dataset, no firms are eliminated. While results obtained using the baseline dataset are reported in section five, results obtained using two alternative datasets are compared as part of robustness checks in section seven.

Two indexes are constructed to be used as instruments – industry specific exchange rate *iser* and industry specific ratio of producer prices in the Czech Republic and abroad *isfp*. Two datasets were combined constructing industry-specific exchange

[16] Hanousek and Kocenda (2008) suggest that in post-transition economies that underwent mass privatization, the control ability of the state in privatized firms might be underestimated. This is possible through so-called golden shares, status of strategic firm, etc.

rates. Bilateral average yearly exchange rates for the Czech currency and currencies of its 26 main trading partners come from the database of the Czech National Bank. Detailed data on bilateral trade at the 3-digit SITC level were provided by the Ministry of Industry and Trade of the Czech Republic. Having SITC categories linked to NACE industry codes, industry specific exchange rates for each industry were constructed as the weighted average of exchange rate indexes with the weights based on the relative importance of export destinations. The value of index *iser* has been set such that *iser* is equal to 1 for each sector in 1997.

To construct *isfp*, sectoral producer price indexes of the 12 most important export destinations have been used in addition to bilateral exchange rates. For each country and each sector, the index of producer prices in local currency was constructed first. Subsequently, the index was recalculated into Czech currency using bilateral exchange rates and the ratio of domestic and foreign producer prices was constructed. Finally, the industry specific ratio of producer prices *isfp* was calculated for each industry as a weighted average of country and industry specific ratios with the weights of countries based on their relative importance as export destinations of Czech firms. The value of index *isfp* was set such that *isfp* is equal to 1 for each sector in 1997. Table A2 in the appendix shows the values of iser and isfp and their year-on-year differences averaged across the 2-digit NACE industry division.

Table 1: The description of variables used

Variable	Corresponding entry from CSO dataset
Output	Revenue from sales of own products and services + change in inventories, adjusted for inflation using industry-specific producer price index
Labor	Average number of employees (recomputed on an eight hour day basis)
Capital	Intangible and tangible fixed assets
Investments	Purchase of intangible and tangible investment goods
Export	Dummy equal to one if firm exports in respective year, zero otherwise
Region	Regional dummies based on the division into eight regions
Industry	Industry dummies based on 2-digit NACE codes
Firstyear	Dummy equal to one if firm exports in the respective year, but did not export in the preceeding year. Zero otherwise.
Firstyear_ei	Variable equal to the ratio of firm's export and revenues if firm exports in the respective year, but did not export in the preceeding year. Zero otherwise.
Iser	Industry specific exchange rate
Isfp	Industry specific ratio of producer prices in the Czech Republic and abroad
Productivity	Three productivity measures are employed: labor productivity based on output, labor productivity based on value added and total factor productivity based on methodology suggested by Levinsohn and Petrin (2000). Each measure is used in the level and growth

5 Results

Unmatched productivity differences between export starters and non-exporters obtained using matching on propensity score approach suggest that the level of labor productivity of export-starters is significantly higher already before they start with exporting (Table 2). Once self selection into exporting is controlled for using matching on propensity score, the average treatment effect on exporters is positive and significant one year after export entry in the level specification. In the logic of previous research papers on learning-by-exporting, this would be considered as an indication of learning-by-exporting. However, as explained in the introduction, this can be also the effect of a new manager taking charge of a company, entering foreign markets and boosting productivity at the same time. The attempt to introduce exogenous shocks by including exchange rates and producer prices among covariates does not provide qualitatively different results. This might be the result of the fact that inclusion of two additional covariates does not change the selection of firms into groups of treated and non-treated much.[17] Unmatched differences in growth rates of labor productivity based on output indicate no significant difference between non-exporters and export starters one year before export entry and in the year of export entry but significantly higher productivity one year later. Estimates employing labor productivity based on value added do not provide any statistically significant results (Table 3). In order not to mix the productivity enhancements gained through foreign owner and learning-by-exporting effects, as explained later in the section six, only domestically owned firms are used in the baseline analysis. This reduction, however, decreases the sample size substantially and might negatively influence the standard errors and significance of estimated coefficients.

[17] The likelihood ratio test does not always suggest statistically significant improvement once two exogenous variables are added.

Table 2: Productivity level and productivity growth differences between export starters and non-exporters:

Labor productivity based on output: matching without exchange rates and producer prices

	Level			*Growth*		
	One year before	*Year of entry*	*One year after*	*One year before*	*Year of entry*	*One year after*
Number of starters	21	21	21	20	21	21
Number of controls	314	310	245	243	310	244
Unmatched difference	**4.80** **	**5.63** **	**7.92** ***	**-0.05**	**0.09**	**0.44** ***
Standard Error	(2.22)	(2.20)	(2.26)	(0.08)	(0.07)	(0.11)
Average treatment effect on treated	**1.35**	**2.34**	**5.74** *	**-0.21**	**0.13**	**0.44**
Standard Error	(2.74)	(3.05)	(2.92)	(0.13)	(0.07)	(0.38)
Average treatment effect	**2.50**	**3.19**	**4.24**	**-0.07**	**0.04**	**0.28**

Labor productivity based on output: matching with exchange rates and producer prices

	Level			*Growth*		
	One year before	*Year of entry*	*One year after*	*One year before*	*Year of entry*	*One year after*
Number of starters	22	22	22	21	22	22
Number of controls	237	238	235	159	238	234
Unmatched difference	**4.89** **	**5.71** **	**8.02** ***	**-0.05**	**0.09**	**0.44** ***
Standard Error	(2.23)	(2.21)	(2.26)	(0.08)	(0.07)	(0.11)
Average treatment effect on treated	**2.73**	**3.66**	**5.49** *	**-0.11**	**0.12**	**0.47**
Standard Error	(2.79)	(2.96)	(3.03)	(0.13)	(0.07)	(0.36)
Average treatment effect	**1.52**	**2.96**	**7.54**	**-0.07**	**0.13**	**0.73**

Table 3: Productivity level and productivity growth differences between export starters and non-exporters: matching on propensity score approach, firms with domestic owners

Labor productivity based on value added: matching without exchange rates and producer prices

	Level			*Growth*		
	One year before	*Year of entry*	*One year after*	*One year before*	*Year of entry*	*One year after*
Number of starters	21	21	21	20	21	21
Number of controls	314	308	242	243	310	244
Unmatched difference	**2.01**	**1.32**	**1.80**	**-0.04**	**0.11**	**-0.22**
Standard Error	(2.19)	(2.08)	(2.14)	(0.12)	(0.71)	(0.80)
Average treatment effect on treated	**1.15**	**0.73**	**-0.90**	**-0.12**	**0.32**	**0.03**
Standard Error	(4.03)	(2.32)	(3.04)	(0.11)	(0.47)	(0.11)
Average treatment effect	**1.78**	**1.33**	**3.18**	**-0.07**	**0.17**	**-0.17**

Labor productivity based on value added: matching with exchange rates and producer prices

	Level			*Growth*		
	One year before	*Year of entry*	*One year after*	*One year before*	*Year of entry*	*One year after*
Number of starters	22	22	21	21	22	22
Number of controls	235	238	232	159	238	234
Unmatched difference	**2.01**	**1.26**	**1.79**	**-0.04**	**0.10**	**-0.22**
Standard Error	(2.21)	(2.09)	(2.15)	(0.12)	(0.72)	(0.81)
Average treatment effect on treated	**-0.76**	**-0.19**	**0.97**	**0.02**	**0.29**	**-2.50**
Standard Error	(4.18)	(2.55)	(3.18)	(0.10)	(0.46)	(2.96)
Average treatment effect	**1.82**	**-0.36**	**0.78**	**-0.04**	**0.09**	**-0.52**

Table 4: Productivity level and productivity growth differences between export starters and non-exporters: regression approach, firms with domestic owners

Labor productivity based on output

		Level			Growth		
		One year before	Year of entry	One year after	One year before	Year of entry	One year after
Fixed Effects	*Firstyear*	**-0.36**	**1.60** **	**0.94**	**0.01**	**0.19** ***	**-0.08**
		(0.88)	(0.73)	(0.66)	(0.08)	(0.06)	(0.05)
	Capital	**1.65** ***	**0.89** **	**0.40**	**-0.20** ***	**-0.19** ***	**-0.02**
		(0.41)	(0.42)	(0.50)	(0.04)	(0.04)	(0.04)
	Labor	**-3.36** ***	**-5.62** ***	**-7.20** ***	**-0.12**	**-0.14** *	**-0.37** ***
		(1.18)	(0.96)	(1.09)	(0.11)	(0.08)	(0.09)
	Number of observations	291	293	243	230	290	240
Fixed Effects IV	*Firstyear*	**2.58**	**-2.21**	**-2.36**	**0.07**	**-0.16**	**0.05**
		(4.08)	(3.78)	(2.95)	(0.30)	(0.35)	(0.25)
	Capital	**1.56** ***	**0.94** **	**0.39**	**-0.21** ***	**-0.18** ***	**-0.02**
		(0.42)	(0.45)	(0.53)	(0.04)	(0.04)	(0.04)
	Labor	**-3.17** **	**-5.79** ***	**-7.21** ***	**0.20**	**-0.18** *	**-0.37** ***
		(1.24)	(1.02)	(1.18)	(0.08)	(0.09)	(0.09)
	Number of observations	286	289	241	226	286	238

Labor productivity based on value added

		Level			Growth		
		One year before	Year of entry	One year after	One year before	Year of entry	One year after
Fixed Effects	*Firstyear*	**-4.01** **	**-1.42**	**0.63**	**-0.07**	**-0.07**	**0.17**
		(2.01)	(1.95)	(1.97)	(0.22)	(0.19)	(0.18)
	Capital	**1.71** *	**0.10**	**0.29**	**-0.11**	**-0.14**	**-0.07**
		(0.93)	(1.12)	(1.47)	(0.10)	(0.11)	(0.14)
	Labor	**1.71**	**-3.49**	**-6.84** *	**-0.22**	**-0.65** ***	**-1.09** ***
		(2.70)	(2.55)	(3.25)	(0.29)	(0.24)	(0.30)
	Number of observations	291	292	242	230	290	240
Fixed Effects IV	*Firstyear*	**7.24**	**-16.37**	**-23.09** **	**0.24**	**-1.85**	**-1.21**
		(9.87)	(11.04)	(11.28)	(0.81)	(1.14)	(0.97)
	Capital	**1.38**	**0.53**	**0.22**	**-0.14**	**-0.09**	**-0.07**
		(1.03)	(1.32)	(2.03)	(0.11)	(0.13)	(0.16)
	Labor	**2.59**	**-4.38**	**-6.93**	**-0.19**	**-0.80** ***	**-1.10** ***
		(3.01)	(2.97)	(4.49)	(0.30)	(0.30)	(0.35)
	Number of observations	286	288	240	226	286	238

Notes: Dependent variables are the logarithms of the levels and growth rates of respective productivity measures. Besides the indicator of the export entry, variable *firstyear,* explanatory variables include logarithms of capital and labor as well as region dummies and a constant.

Regression results in the Table 3 provide a different picture. Fixed effects panel data estimation without instruments suggest that both level and growth of the labor productivity based on output is significantly higher for export starters in the year of export entry. Once instruments are used to evaluate the productivity gains of firms that entered foreign markets due to an exogenous impetus, positive and significant differences diminish. This is in line with the self selection hypothesis and provides no support for learning-by-exporting theory.

Tables 2, 3 and 4 provide results based on labor productivity of domestically owned non-exporters and export starters with changes in export status lasting longer than one year. Results based on the total factor productivity employing the same set of firms are provided in Tables A3 and A4 in the appendix. These provide more support for learning-by-exporting. Positive and significant average treatment effect on treated (i.e., export starters) one year after the export entry can be observed in the level specification in the Table A3. In addition, in the Table A4, fixed effects instrumental variable estimation on levels suggests positive and significant effects of learning-by-exporting in the case of firms that entered foreign markets due to exogenous impetus. Since the productivity estimates based on TFP are residuals from the estimated production functions, coefficients in the first three columns of tables A3 and A4 (comparison in levels) are not directly comparable to the coefficients from the estimations based on labor productivity. Finally, results based on the sample of all firms (including firms with foreign or international owner) are provided in Tables A5, A6 and A7 and discussed in the following section. Table 8 in the appendix provides results of the estimation of the equations (2, 2a and 2b), i.e., the estimation employing export intensity of export starters. This specification, however, provides no evidence of significant differences between the productivity of non-exporters and export starters.

6 Learning-by-Exporting and the Effect of Ownership

As outlined in the introduction, a firm's ownership can affect the potential for learning-by-exporting. A firm controlled by a foreign owner is likely to have access to technology and know-how directly from the foreign owner. For such a firm, the potential for learning by exporting is narrow. However, learning-by-exporting can be an important channel for productivity increases in the case of a firm with a domestic owner.

The issue of ownership is tackled as follows. The effect of learning-by-exporting is estimated separately on the sample of firms with a domestic private owner, on the sample of firms with foreign or international owner and on the sample of all firms. An analysis employing the sample of firms with foreign and international owners provides no significant differences in productivity between non-exporters and export starters at all (tables are not included). This can either reflect the fact that foreign owned firms are in general more productive than domestically owned firms thanks to access to know-how of foreign owners or the very small sample of firms with a foreign or international owner. Once all firms are analyzed, the results presented in Tables A5, A6 and A7 provide, in line with expectations, in average smaller estimates of productivity enhancements than those estimated with domestic firms only. The overall picture, however, remains unchanged.

7 Robustness Checks

A number of robustness checks are performed to examine how sensitive the results are to different specifications. First, three measures of productivity are used: labor productivity based on output, labor productivity based on value added and total factor productivity. Second, I look at the effects of exporting at both levels and growth rates of productivity measures.

The other robustness issue emerges from the possible miscoding in the definition of being an exporter. As indicated in section four, only firms that are observed in all 6 years are included in the dataset. For each year, firms with the exports higher than zero are coded as exporters and firms with zero export as non-exporters. As a result, about 20% of all firms do change their exporting status at least once during the six year period. There is, however, a risk that exports of some firms were not recorded correctly every year and transition between exporting and non-exporting in the case of these firms is just artificial. The most prominent candidates for this group would be firms which did not export only in one year. To examine how this type of miscoding could have influenced the results, I construct three alternative data sets. In the first alternative dataset, all firms which changed their exporting status for one year only are eliminated (benchmark case used for analysis presented in the paper). In the second dataset, all firms are included. In the third alternative dataset, all firms that changed exporting status more than once are eliminated. Comparison of the results based on labor productivity gained using three alternative datasets suggests that the results are robust in the sense that the magnitude and significance of coefficients are comparable across the three datasets.

8 Conclusion

The effect of exporting on productivity is estimated on the sample of firm-level panel data from the Czech Republic. Using matching on propensity score and regression analysis, the goal is to disentangle learning-by-exporting from changes in firm management that bring the firm to enter foreign markets and introduce productivity increasing measures at the same time.

When analyzed without instruments, the estimates provide evidence of an increase of labor productivity based on the output in the year of entry. Once exchange rates and producer prices are used as instruments to focus on firms that started with exporting due to exogenous impetus, productivity enhancements vanish in regression analysis settings. On the other hand, estimates using total factor productivity show no learning effects without using instruments but significantly positive productivity enhancements in the year after export entry for firms that entered foreign markets due to an exogenous reason. Labor productivity based on value added does not provide any evidence of productivity increases, irrespective of the method used.

Differences between the results delivered using different productivity measures suggest that productivity enhancements stemming from managerial effects on one side and learning-by-exporting on the other side could be of different nature. An increase in labor productivity in the year of export entry attributed to the managerial effects is consistent with the story of a new manager who decides to enter foreign markets and cuts labor costs at the same time. On the other hand, more complex productivity enhancements reflected in total factor productivity are likely to be attributed to the learning-by-exporting effects. Although caution is needed when drawing conclusions, most importantly due to data limitations, it seem that disentangling the effects of exporting from the managerial effects is vital when estimating the learning-by-exporting effects.

Appendix

Table A1: Number of export starters and number of non-exporters by industry and year

	1998		1999		2000		2001		2002	
	export starters	non-exporters	export starters	non-exporters	export starters	non-exporters	export starters	non-exporters	export starters	non-exporters
Food products and beverages	11	75	9	72	18	62	12	65	9	68
Tobacco products		1		1	1	1		1		1
Textiles	1	8	7	5	2	4	1	7	2	10
Wearing apparel; dressing and dyeing of fur	2	4	2	3		5	4	3	1	3
Leather and leather products	4			1	2		1		1	3
Wood and wood and cork products, except furniture	1	3	5	2		3	1	4	3	8
Pulp, paper and paper products	4	5	4	3		3	2	4	1	4
Publishing, printing and reproduction of recorded media	5	13	7	12	6	10	3	11	5	13
Coke, refined petroleum products and nuclear fuel										
Chemicals and chemical products	2	7	5	6	4	4	1	4	1	4
Rubber and plastic products	2	2	1	4	1	3		5	1	5
Other non-metallic mineral products	1	9	3	9	2	8	1	8	2	7
Basic metals	4	4	9	2	2	2	1	4	1	5
Fabricated metal products, except machinery and equipment	5	7	6	4		4	3	5	2	8
Machinery and equipment n.e.c.	4	9	5	6	3	4	1	4	1	4
Office machinery and computers		1	1						1	
Electrical machinery and apparatus n.e.c.	5	11	4	10	4	7	3	10	2	15
Radio, television and communication equipment and apparatus	5	6	6	2		3	1	3	3	6
Medical, precision and optical instruments, watches and clocks	2	5	5	3	1	4	2	5	3	6
Motor vehicles, trailers and semi-trailers	1	2	4		1			1		1
Other transport equipment	2	4	5	1		1	1	5		7
Furniture; manufacturing n.e.c.	3	3	3	1	1	2	1	3	1	2
Recycling		4	3	4		4		5	1	9

Table A2: Industry specific exchange rates and producer price ratios

	1998				1999				2000				2001				2002			
	iser	*diser*	*isfp*	*disfp*	*iser*	*diser*	*isfp*	*disfp*	*iser*	*diser*	*isfp*	*disfp*	*iser*	*diser*	*isfp*	*disfp*	*iser*	*diser*	*isfp*	*disfp*
Food products and beverages	0.98	-0.02	0.84	0.02	0.96	-0.02	0.84	0.00	0.95	-0.01	0.84	0.00	0.92	-0.03	0.96	0.12	0.83	-0.09	0.99	0.03
Tobacco products	0.99	-0.01	1.06	0.09	0.94	-0.05	1.49	0.43	0.93	-0.02	1.84	0.35	0.88	-0.05	2.11	0.27	0.79	-0.09	2.51	0.40
Textiles	0.99	-0.01	0.83	0.02	1.01	0.01	0.83	0.00	0.99	-0.02	0.86	0.02	0.95	-0.04	0.89	0.04	0.86	-0.09	0.89	0.00
Wearing apparel; dressing and dyeing of fur	1.00	0.00	0.91	0.04	1.02	0.02	0.93	0.02	1.00	-0.02	0.94	0.01	0.96	-0.04	0.96	0.02	0.87	-0.09	0.96	0.00
Leather and leather products	1.00	0.00	0.91	0.06	1.02	0.02	0.89	-0.02	1.00	-0.02	0.93	0.04	0.95	-0.05	1.03	0.10	0.86	-0.10	1.13	0.10
Wood and wood and cork products, except furniture	1.00	0.00	0.91	0.04	1.02	0.02	0.88	-0.03	1.00	-0.02	0.86	-0.02	0.95	-0.04	0.86	0.00	0.86	-0.10	0.83	-0.03
Pulp, paper and paper products	0.98	-0.02	0.86	0.07	0.97	-0.01	0.85	-0.01	0.96	-0.01	1.05	0.20	0.93	-0.03	1.10	0.05	0.84	-0.09	1.06	-0.04
Publishing, printing and reproduction of recorded media	0.99	-0.01	0.88	-0.01	0.99	0.00	0.93	0.05	0.97	-0.01	0.95	0.02	0.94	-0.03	0.99	0.03	0.85	-0.09	1.00	0.01
Coke, refined petroleum products and nuclear fuel	0.98	-0.02	0.73	-0.08	0.99	0.01	0.84	0.11	0.97	-0.02	1.57	0.73	0.94	-0.03	1.44	-0.13	0.84	-0.10	1.57	0.13
Chemicals and chemical products	0.98	-0.02	0.76	0.02	0.97	-0.01	0.75	0.00	0.97	0.00	0.90	0.14	0.93	-0.04	0.92	0.02	0.84	-0.09	0.89	-0.03
Rubber and plastic products	0.99	-0.01	0.89	0.02	1.01	0.01	0.88	-0.01	0.99	-0.02	0.93	0.05	0.94	-0.04	0.98	0.04	0.85	-0.09	0.96	-0.01
Other non-metallic mineral products	0.99	-0.01	0.80	0.03	1.01	0.02	0.81	0.01	1.00	-0.02	0.83	0.02	0.96	-0.04	0.91	0.08	0.86	-0.10	0.94	0.03
Basic metals	0.99	-0.01	0.86	0.06	1.00	0.01	0.76	-0.10	0.99	-0.01	0.92	0.16	0.95	-0.04	0.90	-0.02	0.85	-0.09	0.87	-0.03
Fabricated metal products, except machinery and equipment	0.99	-0.01	0.91	0.02	1.01	0.02	0.92	0.01	1.00	-0.02	0.91	-0.01	0.95	-0.04	0.94	0.03	0.86	-0.10	0.96	0.01
Machinery and equipment n.e.c.	0.99	-0.01	0.84	0.03	1.01	0.02	0.88	0.04	1.00	-0.02	0.90	0.02	0.96	-0.04	0.93	0.02	0.87	-0.09	0.95	0.03
Office machinery and computers	1.00	0.00	0.66	0.05	1.02	0.02	0.62	-0.04	1.01	-0.01	0.49	-0.13	0.96	-0.04	0.46	-0.03	0.87	-0.10	0.54	0.08
Electrical machinery and apparatus n.e.c.	1.00	0.00	0.94	0.01	1.02	0.02	0.92	-0.02	1.00	-0.02	0.91	-0.01	0.96	-0.04	0.93	0.02	0.86	-0.10	0.94	0.01
Radio, television and communication equipment and apparatus	1.00	0.00	0.73	0.04	1.03	0.03	0.61	-0.13	1.04	0.01	0.58	-0.03	0.99	-0.05	0.50	-0.08	0.87	-0.12	0.59	0.08
Medical, precision and optical instruments, watches and clocks	1.00	0.00	0.92	0.02	1.01	0.02	0.92	0.00	0.99	-0.02	0.94	0.02	0.96	-0.04	0.95	0.02	0.86	-0.09	0.97	0.02
Motor vehicles, trailers and semi-trailers	0.99	-0.01	0.89	0.07	1.01	0.01	0.91	0.02	0.99	-0.02	0.91	0.00	0.95	-0.04	0.93	0.02	0.86	-0.10	0.96	0.03
Other transport equipment	0.99	-0.01	0.71	0.16	1.01	0.02	0.70	-0.01	1.00	-0.01	0.76	0.06	0.98	-0.02	0.57	-0.19	0.87	-0.11	0.68	0.11
Furniture; manufacturing n.e.c.	1.00	0.00	0.89	0.03	1.03	0.03	0.93	0.04	1.02	-0.01	0.95	0.02	0.98	-0.04	0.99	0.04	0.88	-0.10	1.02	0.04

Note: Iser denotes industry specific exchange rate. Isfp denotes industry specific producer price ratio. Diser and Disfp are their respective year-on-year differences.

Table A3: Productivity level and productivity growth differences between export starters and non-exporters: matching on propensity score approach, firms with domestic owners

Total factor productivity: matching without exchange rates and producer prices

	Level			Growth		
	One year before	*Year of entry*	*One year after*	*One year before*	*Year of entry*	*One year after*
Number of starters	19	18	18	17	18	17
Number of controls	250	268	219	184	244	207
Unmatched difference	**-79.71**	**607.55** ***	**93.48**	**-0.03**	**-0.06**	**-0.03**
Standard Error	(58.82)	(129.70)	(83.70)	(0.04)	(0.03)	(0.03)
Average treatment effect on treated	**99.12**	**695.34**	**50.99**	**0.04**	**-0.08**	**-0.04**
Standard Error	-(106.07)	(480.00)	(37.13)	(0.03)	(0.08)	(0.05)
Average treatment effect	**-1.76**	**202.97**	**93.22**	**0.00**	**-0.03**	**-0.01**

Total factor productivity: matching with exchange rates and producer prices

	Level			Growth		
	One year before	*Year of entry*	*One year after*	*One year before*	*Year of entry*	*One year after*
Number of starters	19	19	20	17	18	18
Number of controls	178	171	197	94	167	198
Unmatched difference	**-81.51**	**604.82** ***	**93.63**	**-0.03**	**-0.06**	**-0.03**
Standard Error	(58.82)	(129.94)	(83.89)	(0.04)	(0.03)	(0.03)
Average treatment effect on treated	**-104.51**	**576.57**	**81.43** *	**-0.04**	**-0.05**	**-0.05**
Standard Error	(134.20)	(448.82)	(46.94)	(0.04)	(0.05)	(0.04)
Average treatment effect	**-111.62**	**460.74**	**99.66**	**-0.01**	**-0.01**	**0.00**

Table A4: Productivity level and productivity growth differences between export starters and non-exporters: regression approach, firms with domestic owners

Total factor productivity

		Level			Growth		
		One year before	*Year of entry*	*One year after*	*One year before*	*Year of entry*	*One year after*
Fixed Effects	*Firstyear*	**-141.68** ***	**151.18** ***	**19.16**	**-0.10** *	**-0.06**	**0.02**
		(51.79)	(47.37)	(20.16)	(0.06)	(0.04)	(0.05)
	Capital	**20.87**	**37.02**	**16.49**	**0.05**	**0.02**	**0.01**
		(23.82)	(27.28)	(15.03)	(0.03)	(0.03)	(0.04)
	Labor	**-2.78**	**46.40**	**-9.44**	**-0.08**	**-0.04**	**0.00**
		(69.31)	(61.92)	(33.21)	(0.08)	(0.06)	(0.08)
	Number of observations	291	293	243	217	276	231
Fixed Effects IV	*Firstyear*	**-52.67**	**386.25**	**208.92** **	**-0.39** *	**-0.08**	**0.05**
		(235.61)	(246.92)	(103.93)	(0.22)	(0.19)	(0.19)
	Capital	**20.23**	**30.73**	**16.88**	**0.07**	**0.03**	**0.02**
		(24.55)	(29.54)	(18.73)	(0.04)	(0.03)	(0.04)
	Labor	**12.19**	**68.17**	**-9.02**	**-0.09**	**-0.04**	**0.00**
		(71.92)	(66.43)	(41.39)	(0.09)	(0.06)	(0.08)
	Number of observations	286	289	241	213	272	229

Notes: Dependent variables are the logarithms of the levels and growth rates of respective productivity measures. Besides the indicator of export entry, variable *firstyear,* explanatory variables include logarithms of capital and labor as well as region dummies and a constant.

Table A5: Productivity level and productivity growth differences between export starters and non-exporters: matching on propensity score approach, all firms

Labor productivity based on output: matching without exchange rates and producer prices

	Level			*Growth*		
	One year before	*Year of entry*	*One year after*	*One year before*	*Year of entry*	*One year after*
Number of starters	35	35	35	33	35	35
Number of controls	414	406	322	318	406	321
Unmatched difference	**4.26** **	**4.85** ***	**6.23** ***	**-0.03**	**0.09**	**0.27** ***
Standard Error	(1.75)	(1.76)	(1.84)	(0.06)	(0.05)	(0.08)
Average treatment effect on treated	**1.81**	**7.19** ***	**2.42**	**-0.04**	**0.12** *	**0.28**
Standard Error	(2.42)	(2.46)	(2.82)	(0.06)	(0.06)	(0.23)
Average treatment effect	**2.32**	**2.85**	**3.77**	**-0.07**	**-0.01**	**0.31**

Labor productivity based on output: matching with exchange rates and producer prices

	Level			*Growth*		
	One year before	*Year of entry*	*One year after*	*One year before*	*Year of entry*	*One year after*
Number of starters	36	36	35	32	36	35
Number of controls	402	394	318	258	394	317
Unmatched difference	**4.32** **	**4.91** ***	**6.29** ***	**-0.02**	**0.09** **	**0.27** ***
Standard Error	(1.76)	(1.77)	(1.84)	(0.06)	(0.05)	(0.08)
Average treatment effect on treated	**4.83**	**2.67**	**5.26** **	**-0.01**	**0.04**	**0.25**
Standard Error	(2.96)	(2.53)	(2.47)	(0.05)	(0.10)	(0.23)
Average treatment effect	**0.39**	**1.45**	**4.52**	**-0.08**	**0.06**	**0.31**

Table A6: Productivity level and productivity growth differences between export starters and non-exporters: matching on propensity score approach, all firms

Labor productivity based on value added: matching without exchange rates and producer prices

	Level			*Growth*		
	One year before	*Year of entry*	*One year after*	*One year before*	*Year of entry*	*One year after*
Number of starters	34	34	35	33	35	35
Number of controls	409	401	317	318	406	321
Unmatched difference	**3.26** **	**2.50**	**1.82**	**-0.01**	**-0.01**	**-0.29**
Standard Error	(1.79)	(1.69)	(1.79)	(0.15)	(0.49)	(0.55)
Average treatment effect on treated	**3.74**	**0.89**	**1.36**	**-0.06**	**0.21**	**-0.08**
Standard Error	(2.79)	(2.46)	(2.79)	(0.11)	(0.29)	(0.17)
Average treatment effect	**0.83**	**0.84**	**0.69**	**-0.02**	**0.04**	**-0.27**

Labor productivity based on value added: matching with exchange rates and producer prices

	Level			*Growth*		
	One year before	*Year of entry*	*One year after*	*One year before*	*Year of entry*	*One year after*
Number of starters	35	35	35	32	36	35
Number of controls	397	389	313	258	394	317
Unmatched difference	**3.27** **	**2.47**	**1.80**	**-0.01**	**-0.01**	**-0.29**
Standard Error	(1.80)	(1.70)	(1.80)	(0.15)	(0.50)	(0.55)
Average treatment effect on treated	**2.04**	**3.05**	**1.30**	**-0.40**	**0.16**	**-0.33**
Standard Error	(3.05)	(2.74)	(2.86)	(0.34)	(0.28)	(0.21)
Average treatment effect	**0.46**	**1.15**	**0.40**	**-0.18**	**0.22**	**-0.21**

Table A7: Productivity level and productivity growth differences between export starters and non-exporters: regression approach, all firms

Labor productivity based on output

		Level			*Growth*		
		One year before	*Year of entry*	*One year after*	*One year before*	*Year of entry*	*One year after*
Fixed Effects	*Firstyear*	**0.03**	**1.61** ***	**1.20** **	**0.02**	**0.16** ***	**-0.07**
		(0.65)	(0.56)	(0.56)	(0.06)	(0.05)	(0.05)
	Capital	**1.28** ***	**1.38** ***	**1.16** ***	**-0.13** ***	**-0.08** ***	**0.08** **
		(0.32)	(0.31)	(0.45)	(0.03)	(0.03)	(0.04)
	Labor	**-5.29** ***	**-5.70** ***	**-6.24** ***	**-0.22** **	**-0.09**	**-0.27** ***
		(0.93)	(0.79)	(0.93)	(0.09)	(0.07)	(0.08)
	Number of observations	389	393	326	306	388	322
Fixed Effects IV	*Firstyear*	**0.96**	**-1.02**	**-2.63**	**0.15**	**0.12**	**0.19**
		(3.11)	(2.90)	(3.41)	(0.42)	(0.27)	(0.33)
	Capital	**1.22** ***	**1.49** ***	**1.24** **	**-0.14**	**-0.08** **	**0.08** *
		(0.35)	(0.35)	(0.49)	(0.04)	(0.03)	(0.04)
	Labor	**-5.24** ***	**-5.74** ***	**-5.87** ***	**-0.22**	**-0.09**	**-0.31** ***
		(0.97)	(0.81)	(1.09)	(0.10)	(0.08)	(0.10)
	Number of observations	383	388	322	301	384	319

Labor productivity based on value added

		Level			*Growth*		
		One year before	*Year of entry*	*One year after*	*One year before*	*Year of entry*	*One year after*
Fixed Effects	*Firstyear*	**-2.01**	**0.04**	**-2.43**	**-0.23**	**-0.02**	**-0.08**
		(1.64)	(1.43)	(7.14)	(0.25)	(0.20)	(0.17)
	Capital	**1.61** **	**1.56** **	**1.66** *	**-0.08**	**-0.11**	**0.03**
		(0.80)	(0.78)	(0.87)	(0.12)	(0.11)	(0.14)
	Labor	**-3.28**	**-5.57** ***	**-5.65** ***	**0.05**	**-0.07**	**-0.55** *
		(2.31)	(1.98)	(2.01)	(0.36)	(0.28)	(0.28)
	Number of observations	383	388	383	306	388	322
Fixed Effects IV	*Firstyear*	**0.18**	**1.06**	**-3.62**	**1.81**	**-0.39**	**-0.41**
		(7.85)	(1.42)	(8.06)	(1.92)	(1.02)	(1.10)
	Capital	**1.48** *	**1.50**	**1.58**	**-0.24**	**-0.10**	**0.02**
		(0.86)	(1.13)	(1.17)	(0.20)	(0.12)	(0.14)
	Labor	**-3.12**	**-6.42**	**-5.89** **	**0.20**	**-0.09**	**-0.51**
		(2.43)	(2.35)	(2.59)	(0.44)	(0.28)	(0.32)
	Number of observations	377	322	318	301	384	319

Notes: Dependent variables are the logarithms of the levels and growth rates of respective productivity measures. Besides the indicator of the export entry, variable firstyear explanatory variables include logarithms of capital and labor as well as region dummies and a constant.

Table A8: Productivity level and productivity growth differences between export starters and non-exporters: regression approach with export intensity, firms with domestic owners

Labor productivity based on output

		Level			Growth		
		One year before	*Year of entry*	*One year after*	*One year before*	*Year of entry*	*One year after*
Fixed Effects	*Firstyear export intensity*	**-1.07**	**3.27**	**4.58**	**-0.34**	**0.62**	**-0.16**
		(6.74)	(5.71)	(4.86)	(0.59)	(0.50)	(0.40)
	Capital	**1.58** ***	**0.94** **	**0.46**	**-0.21** ***	**-0.18** ***	**0.01**
		(0.42)	(0.43)	(0.49)	(0.04)	(0.04)	(0.04)
	Labor	**-4.15** ***	**-5.69** ***	**-5.16** ***	**-0.24** *	**-0.15** *	**-0.21** **
		(1.49)	(0.97)	(1.13)	(0.12)	(0.09)	(0.09)
	Number of observations	278	293	233	220	290	233
Fixed Effects IV	*Firstyear export intensity*	**33.85**	**8.55**	**7.85**	**-2.12**	**1.22**	**0.77**
		(36.89)	(27.45)	(24.10)	(2.94)	(2.46)	(1.99)
	Capital	**1.62** ***	**0.88** **	**0.47**	**-0.22**	**-0.18** ***	**0.02**
		(0.44)	(0.42)	(0.50)	(0.04)	(0.04)	(0.04)
	Labor	**-3.17** *	**-5.59** ***	**-5.11** ***	**-0.27**	**-0.15** *	**-0.20** **
		(1.80)	(0.97)	(1.17)	(0.14)	(0.09)	(0.10)
	Number of observations	274	289	231	217	286	231

Labor productivity based on value added

		Level			Growth		
		One year before	*Year of entry*	*One year after*	*One year before*	*Year of entry*	*One year after*
Fixed Effects	*Firstyear export intensity*	**12.86**	**2.90**	**-2.23**	**0.33**	**-0.21**	**-0.27**
		(11.25)	(15.06)	(14.11)	(1.54)	(1.42)	(1.07)
	Capital	**1.65** **	**0.05**	**0.32**	**-0.11**	**-0.14**	**0.05**
		(0.69)	(1.12)	(1.42)	(0.10)	(0.11)	(0.11)
	Labor	**-3.06**	**-3.39**	**1.38**	**-0.13**	**-0.65** ***	**0.06**
		(2.48)	(2.55)	(3.28)	(0.32)	(0.24)	(0.25)
	Number of observations	278	292	232	220	290	233
Fixed Effects IV	*Firstyear export intensity*	**68.42**	**86.55**	**9.79**	**0.93**	**-0.13**	**-3.16**
		(61.66)	(79.94)	(69.85)	(7.40)	(7.03)	(5.40)
	Capital	**1.67** **	**0.14**	**0.37**	**-0.11**	**-0.14**	**0.04**
		(0.74)	(1.21)	(1.45)	(0.10)	(0.11)	(0.11)
	Labor	**-1.56**	**-2.75**	**1.55**	**-0.11**	**-0.65**	**0.02**
		(3.02)	(2.82)	(3.42)	(0.35)	(0.25) ***	(0.26)
	Number of observations	274	288	230	217	286	231

Notes: Dependent variables are the logarithms of the levels and growth rates of respective productivity measures. Besides the indicator of the export entry and export intensity, explanatory variables include logarithms of capital and labor as well as region dummies and a constant.

Figure 1: Histograms of export intensity (for individual industries, exporters only)

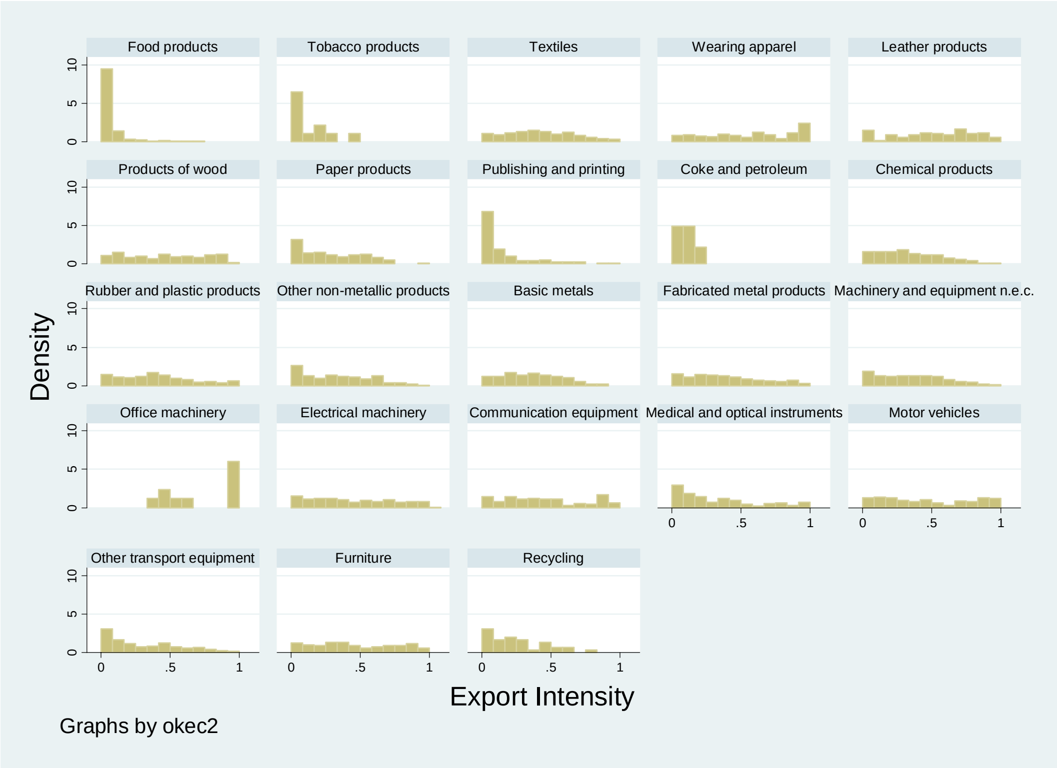
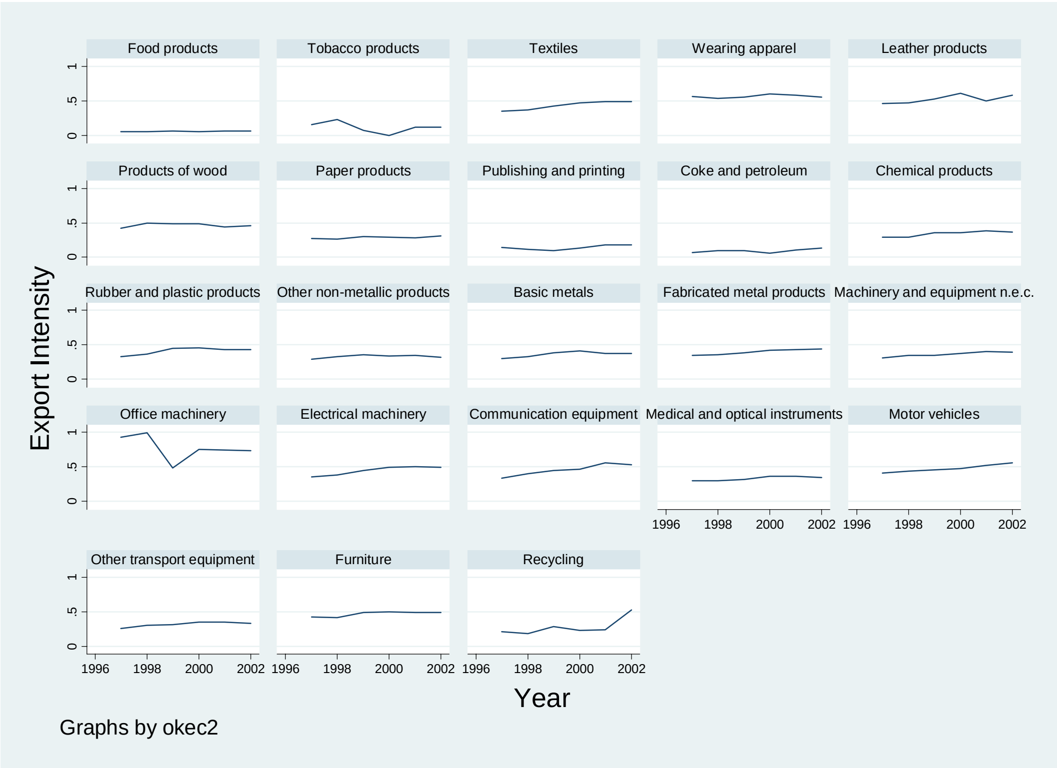


Figure 2: Evolution of export intensity across time (for individual industries, exporters only)



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Exporting Behavior of Firms: How Do Multinationals Change International Trade?

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Abstract

This paper analyzes a firm's decision to enter and exit foreign markets through exporting. Employing firm-level data from the Czech Republic, results suggest that entry sunk costs are significant and substantial, although no significant differences are found between sunk costs incurred by domestic and foreign-owned firms. Exchange rate level is an important factor influencing participation in export, though firms with a foreign owner are twice less responsive to exchange rate changes than are domestic private and domestic state firms. Higher volatility of exchange rate significantly decreases the probability of future exporting for firms with a foreign owner. In the search for spillovers, the results are mixed. Proximity to an exporting firm (either in geographic or sectoral terms) has, surprisingly, a negative effect on the decision of a firm to export in four specifications and a positive effect in one specification.

JEL classification: C23, F23, D21
Keywords: export, exchange rate, panel data, multinationals

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1 Introduction

The purpose of the present study is to examine the exporting behavior of firms in the Czech Republic, with an emphasis on the differences between firms controlled by domestic and foreign owners. Taking into account the high ratio of inward and outward foreign direct investments in the Czech Republic, foreign ownership is a good indicator of the multinational status of a firm.[3] Results of the paper thus suggest how increasingly important multinational corporations change the patterns of international trade in small open economies. Three major areas are investigated: First, the importance of sunk costs of exporting is estimated. Second, the responsiveness of firms to changes in exchange rate level and its volatility is explored. Finally, the role of spillovers that influence the exporting of other firms is investigated.

The paper is organized as follows. Section 2 provides a motivation focused primarily on the responsiveness of a firm's exporting behavior to exchange rate changes, while the literature review section surveys firm-level studies of exporting behavior as well as other related trade literature. Section 4 focuses on the estimation strategy. Data used in the study are described in section 5, section 6 summarizes empirical results, and the final section outlines further work on the paper.

2 Motivation

In all countries, but specifically in small open economies, a change of exchange rate leading to a significant change in aggregate exports can strongly influence a country's macroeconomic development. Due to hysteresis in trade, even temporary changes in exchange rates can lead to permanent changes in international trade flows.[4] In the case of transition countries, the effects of exchange rate changes on aggregate exports are even more pronounced due to the relatively high vulnerability of firms. Therefore, politicians and central bankers of small transition countries are likely to be concerned about the level of exchange rate and its effect on exporters.

[3] In their seminal work on the role of multinationals in exporting behavior, Aitken, Hanson and Harrison (1997) define multinational enterprises as firms with positive foreign equity ownership.
[4] Hysteresis in trade describes the situation in which suitable conditions (e.g. depreciation of the exchange rate or the removal of tariffs) enable a firm to enter foreign markets (because expected returns exceed sunk costs), but the firm doesn't exit foreign markets when initial conditions are re-established.

Indeed, when in 2001 the exchange rate of the Czech koruna against the Euro appreciated by 8.5% over twelve months and due to the recession in Germany the foreign trade deficit of the Czech Republic reached an all-time high of CZK 22 billion in December 2001, a discussion about the "correct" level of exchange was already underway. "The current exchange rate and mainly the trend is, I'm not afraid to say it, homicidal,"[5] suggested Vratislav Kulhánek, former CEO of Škoda Auto a.s., the largest Czech exporter (the firm is owned by a German-based multinational). One month later, the Czech National Bank in cooperation with the government announced measures aimed at stopping the appreciation of the Czech currency.[6]

But was the exchange rate "homicidal" for all exporters? Certainly not. At the end of 2001, CzechTrade (a government agency promoting export) surveyed 1500 exporting firms.[7] Although nearly half of the firms (mostly small and medium enterprises) perceived the currency appreciation negatively, most reported that they had nevertheless continued to export the same volume; only their profits had been reduced. On the other hand, 27% of exporting firms regarded the appreciation positively. Most of these were medium and large enterprises that are likely to hedge against exchange rate risk.

What are the determinants of a firm's export responsiveness to exchange rate changes? Does ownership matter? Are firms owned by a foreign owner more likely to export? There are several reasons to expect that ownership matters in exporting. Foreign owners can provide exporting know-how and information about target markets, which can decrease the initial sunk costs of entry into a foreign market. Multinationals are likely to be less responsive to exchange rate changes due to internal pricing or long-run decisions about locations of plants in different countries. Reputation can also play a role – once exchange rates change and production of the same good is no longer profitable in one country, a reputable multinational may prefer to produce with a loss for an extended period of time than to stop supplying the

[5] Interview for ČRo 1, Radiožurnál , 22.11.2001. Available in Czech at www.cnb.cz, web page of the Czech National Bank.
[6] These included the transfer of privatization proceeds directly into the foreign exchange reserves of the central bank.
[7] Available in Czech at www.czechtrade.cz

market with that good. With the increasing importance of multinationals, knowledge of differences in export responsiveness between domestic and foreign-owned firms can predict changes in aggregate responsiveness as well as influence policy-making.

Besides inspecting the responsiveness of exporters to exchange rate changes, I devote part of this paper to examining how spillovers influence exporters. The general idea behind this is relatively simple. Knowledge of foreign markets can spread from firm to firm through contacts between firms in a region, through migration of employees within an industry, or through the contacts between suppliers and their clients. Also, an increased concentration of exporters in a region can foster the formation of a transportation infrastructure that subsequently increases the likelihood of neighboring firms to export. Possible spillovers from the presence of multinationals or the presence of exporting firms are important from a policy-making perspective, yet the literature on the issue is relatively scant.

This paper relates to previous studies that employ firm-level panel data to identify and quantify the determinants of a firm's decision to export and to study the firm's export responsiveness to exchange rate changes in terms of both level and volatility. In particular, I am looking for differences between domestic and foreign-owned firms. In addition, I plan to inspect possible spillovers from the presence of foreign firms or exporting firms on the exporting behavior of firms.

3 Overview of the Literature

Relevant literature on the exporting behavior of firms starts[8] with the theoretical frameworks built by Baldwin (1989), Baldwin and Krugman (1989), and Dixit (1989), who emphasize that the presence of sunk costs leads to hysteresis in trade. Hysteresis describes the situation in which suitable conditions (e.g., the depreciation of the exchange rate or the removal of tariffs) enable a firm to enter foreign markets (because expected returns exceed sunk costs), but the firm doesn't exit foreign markets when initial conditions are re-established. Hysteresis has clear implications for international trade in that macroeconomic shocks, temporary changes in exchange rate or policy changes could permanently change the pattern of international trade flows and consequently equilibrium exchange rates.

The first empirical support for the trade hysteresis hypothesis (i.e., the hypothesis that sunk costs are important in international trade) to employ firm-level data was that of Roberts and Tybout (1997). The authors estimate a dynamic discrete-choice model that explains the exporting status of a firm by its exporting history, observed characteristics, and unobserved serially correlated shocks. Using panel data on Colombian manufacturing firms, Roberts and Tybout confirm the trade hysteresis hypothesis. In addition, the authors show that the benefit of the exporting experience decreases once a firm exits foreign markets, and becomes irrelevant after two years. As for the other characteristics of exporting firms, the authors indicate that firms that are large and old are more likely to export. In reaction to the paper of Roberts and Tybout, Campa (2004) employs data on Spanish manufacturers and extends the research by breaking down the adjustments of export supply into intensive and extensive margins, i.e., the changes in volume exported by firms that are already exporting and adjustments caused by the change in the number of exporters. In accordance with Roberts and Tybout (1997), Campa supports the relevance of sunk costs, but shows that the effect of hysteresis is relatively small. He emphasizes that the bulk of changes in aggregate exported volume comes from changes in the exported volumes of existing exporters rather than from a change in the number of exporters. In addition, Campa's results indicate that neither the firm's decision to

[8] For a survey of earlier studies on exporting behavior, see Bilkey (1978).

participate in exporting nor the decision about the exported volume depends on the exchange rate volatility.

In a related study of exporting behavior that employs firm-level panel data, Bernard and Jensen (2004) build on a similar strategy as Roberts and Tybout (1997) and examine not only the effects of entry costs, firm characteristics, but also spillovers from neighboring exporters and the effects of government export promotion policies on the decision to export. Using data on U.S. firms for the years 1984-1992, Bernard and Jensen support the results of Roberts and Tybout (1997) by showing that entry sunk costs are significant. On the other hand, the effects of export promotion policies examined in Bernard and Jensen (2004) are insignificant and geographic and industry spillovers turn out to be negative. Regarding the effects of ownership, the authors find the effect of belonging to a multinational to be significant and to increase the probability of exporting by 1.7%.

Bernard and Jensen (2004) are, however, not the first to study the role of spillovers in exporting behavior. In the context of exporting, spillovers can occur for instance when information about foreign markets or about bureaucratic procedures connected with exporting leaks from one firm to another, either through contacts between firms or through movements of the labor force. Another form of spillover occurs when the regional concentration of exporters makes it feasible to build a transportation infrastructure that increases the probability of exporting for other firms. Aitken, Hanson and Harrison (1997) in their seminal paper test the hypothesis that the exporting activity of one firm increases the likelihood that other firms export. In particular, the authors study whether proximity to multinationals increases a firm's probability of exporting. Their findings show that multinationals indeed act as an export catalyst for domestic firms; however, the authors conclude that no spillovers are generated by the exporting firm in general. The hypothesis that domestic firms learn to export from multinationals is tested also by Greenaway, Sousa and Wakelin (2004), who find positive spillovers in the behavior of UK firms. According to their results, multinationals increase not only the probability of domestic firms to export, but also the export propensity of exporting firms.

Damijan, Polanec and Prasnikar (2004) employ data on Slovenian firms to evaluate the importance of fixed costs and to test a hypothesis about the different directions of causality between exporting and productivity. Since the Slovenian data allow the authors to differentiate between different foreign markets, they examine how firms enter additional foreign markets over time and whether there exists any link between the choice of foreign market and productivity level. Damijan, Polanec and Prasnikar show that firms enter additional foreign markets gradually – one new market in two years on average. In addition, they show that a higher productivity level is required for firms to start exporting to advanced countries compared to less developed countries. As for the productivity gains induced by exporting, the authors suggest that a firm can improve its productivity significantly, but only if it exports to advanced countries.

In terms of empirical strategy, an interesting addition to the research outlined above is the paper of Das, Roberts and Tybout (2001). Unlike Roberts and Tybout (1997), Campa (2004) and Bernard and Jensen (2004), who used a non-structural approach to the probability of exporting, Das, Roberts and Tybout (2001) opt for a structural approach. Although the methodology differs, the results are in accordance with studies employing non-structural estimation. Using a small sample of Colombian chemical producers, the authors confirm that sunk entry costs are substantial. As for export promotion policies, the authors argue that subsidies proportional to export revenues are more efficient than subsidies reducing the entry sunk costs.

The role of innovation as an important factor in the exporting decision of a heterogeneous firm has been recognized in several studies, e.g., Basile (2001) shows that innovations increase the probability that Italian firms export. On the contrary, Wakelin (1996), using a sample of UK firms, concludes that more innovative firms are less likely to export although the number of innovations increases the probability of innovative firms to export. Finally, employing data on Spanish firms, Barrios, Goerg and Strobl (2003) find that the R&D activity of a firm positively influences its decision to export as well as its propensity to export. However, according to the results of their estimations, only foreign firms benefit from the R&D spillovers produced by other foreign firms in terms of export participation. As for the export propensity, both foreign and domestic firms are positively influenced by the R&D spillovers.

Another stream of literature reacts to the common view that exporting increases technological productivity and is based on numerous observations that exporters are more efficient than non-exporters. In an effort to explain the positive relationship between exporting experience and efficiency, Clerides, Lach and Tybout (1998) investigate whether exporters become more efficient after they enter foreign markets or whether self-selection is behind the positive correlation and firms become exporters due to their superior characteristics. Firm-level panel data are employed in their paper to build an export participation model needed to test for self-selection. The results, based on a sample of firms from Colombia, Mexico and Morocco, support the first direction in causality, i.e., more productive firms become exporters. The opposite causal direction turns out to be insignificant, so that exporting experience in fact does not improve efficiency. In an attempt to answer the question of causality between export and productivity, several studies follow the seminal work of Clerides, Lach and Tybout (1998). While Bernard and Jensen (1999) and Isgut 2001) as well as Arnold and Hussinger (2004) find self-selection significant, no support is found for learning-by-exporting. Delgado, Farinas and Ruano (2002) find evidence of self-selection along with evidence of learning-by-exporting limited to young exporters. Learning-by exporting has been further studied in Girma, Greenway and Kneller (2002), Castellani (2002), Bigsten et al. (2004), Wagner (2002) and Saxa (2008).

4 Estimation strategy

The model is based on the theoretical frameworks built by Baldwin (1989), Baldwin and Krugman (1989), and Dixit (1989) and follows closely the models used by Campa (2004), Bernard and Jensen (2004), and Roberts and Tybout (1997).[9] In each period t, a profit-maximizing firm i operating in monopolistic competition has to decide whether to export or not. If the firm enters the foreign market (exporting in the current period but not exporting in the previous period), it incurs entry costs C_{ENTER}. Entry costs can include the costs of market research or the costs of building a distributional network. Let Q_{it}, e_t be the volume exported by firm i in period t and exchange rate in

[9] A noticeable difference in the model employed by Roberts and Tybout (1997) is the presence of time-dependent re-entry costs that allow for differentiating the costs of entry after a different number of periods since the last exporting experience. In contrast, Bernard and Jensen (2004) assume time invariant entry costs and no exit costs. Campa (2004) assumes time invariant entry and exit costs.

period t, respectively. Let $\pi_{it}(Q_{it}, e_t)$ be the profit from exporting earned in period t by firm i (without entry and exit costs) and let I_{ik} indicate whether firm i exports in period k (I_{ik} =1) or not (I_{ik} =0). Then the net expected revenue R_{it} of firm i in period t is defined as

$$R_{it}(I_{it}) = \pi_{it}(Q_{it}, e_t) - (1 - I_{1t-1})C_{ENTER,i}. \tag{1}$$

In each period, the firm maximizes the present discounted value of future profits. The condition indicating the export participation of firm i in period t is then

$$\pi_{it}(Q_{it}, e_t) + \beta\left(E_t\left[V_{it+1}(\Omega_{it}) \mid I_{it} = 1\right] - E_t\left[V_{it+1}(\Omega_{it}) \mid I_{it} = 0\right]\right) + \left(C_{ENTER,i}(I_{it-1} - 1)\right) \geq 0, \tag{2}$$

where β is the discount factor and Ω_{ik} is the information set available to firm i in period k. Firm i exports in period t (I_{it} = 1) if the latter condition is fulfilled, otherwise the firm does not export (I_{it} = 0). The estimation equation of the export participation decision is then derived from (2) and can be written as

$$I_{it} = \begin{cases} 1 ... if ... L \geq 0 \\ 0 ... otherwise \end{cases}, \tag{3}$$

where

$$L = \pi_{it} + \beta\left(E_t\left[V_{it+1}(\Omega_{it}) \mid I_{it} = 1\right] - E_t\left[V_{it+1}(\Omega_{it}) \mid I_{it} = 0\right]\right) + C_{ENTER,i}\left(I_{it} - 1\right) \tag{4}$$

Although it is possible to estimate (3) in its structural form, I follow the strategy advocated by Roberts and Tybout (1997) as well as Bernard and Jensen (2004) and Campa (2004), and I assume that the expected profit from exporting L can be represented as $\alpha I_{it} + \beta Z_{it} + \varepsilon_{it}$ where Z_{it} are firm i characteristics in time t. The basic equation used for the estimation of export participation is then the following:

$$\begin{aligned} exp_{i,t} = {} & \alpha exp_{i,t-1} + \beta_1 iser_{i,t} + \beta_2 empl_{i,t-1} + \beta_3 wage_{i,t-1} + \beta_4 inv_{i,t-1} + \\ & \sum_j \gamma_j own_{i,t,j} + \sum_k \gamma_k year_{i,t,k} + \sum_l \gamma_l ind_{l,k} + \varepsilon_{i,t} \end{aligned}, \tag{5}$$

where $exp_{i,t}$ denotes exporting status of firm i in year t, $iser_{i,t}$ is the industry-specific exchange rate, $empl_{i,t}$ is employment, $wage_{i,t}$ is the average wage of employee, $inv_{i,t}$ denotes investments, $own_{i,t,j}$, $year_{i,t,k}$ and $ind_{i,l}$ are dummies for the type of ownership, year and industry. The error term ε_{it} is described in the next paragraph.

The decision regarding the estimation strategy of (5) is far from being unambiguous. The unobserved heterogeneity of firms (e.g., managerial ability or product quality) is likely to be correlated over time and ignoring this serial correlation would produce bias in the estimation of the coefficient α. The studies mentioned above employ different approaches to estimating the equation of interest. While Roberts and Tybout (1997) use the method of simulated moments, Campa (2004) suggests a random effect probit estimated using maximum likelihood. Bernard and Jensen (2004) advocate an Arellano-Bond GMM estimator to avoid problems with modeling the unobserved effects as fixed, but provide also linear probability estimates as well as fixed effects estimates. The linear probability model is appealing, since it allows for the use of instrumental variables and is generally more robust (Angrist and Krueger 2001). I provide the results delivered using four estimators, namely ordinary least squares, fixed effects, probit and GMM estimator.

To analyze the responsiveness of exporting status to exchange rate levels and volatility with respect to different types of ownership, the right side of (5) is augmented. In the first step, interactions between $iser_{i,t}$ and $own_{i,t,j}$ are included. Another three specifications include interactions between $iser_{i,t}$ lagged by one year and $own_{i,t,j}$ as well as interactions between the measure of exchange rate volatility $isvolatility_{i,t}$ and $own_{i,t,j}$ and lagged $isvolatility_{i,t}$ and $own_{i,t,j}$, respectively.

5 Data and Basic Statistics

5.1 Firm-level data

Firm-level panel data provided by the Czech Statistical Office are employed in the study. Due to the absence of foreign trade data prior to 1997, the study is based on the years 1997-2002. To maintain consistency, detailed data cleaning was performed. Firms that do not occur in the sample every year over the six-year period and non-manufacturing firms[10] were eliminated. Also, due to the relatively small number of firms owned by municipalities, associations and cooperatives, those were eliminated as well. In the end, I have a continuing sample of 1796 manufacturing firms employing in total 611,755 to 717,492 people in different years, i.e., roughly 50% of all people working in Czech manufacturing firms.

For each firm, ownership is defined as follows. If domestic private, domestic state or foreign owners control more than 50% of a firm, then the ownership indicator takes the value of private, state, or foreign, respectively. If a firm is owned by domestic owners only, but no ownership type controls more than 50%, the ownership indicator takes the value of mixed. Finally, if foreign owners control not more than 50% of a firm, the ownership indicator is international.

Besides other firm characteristics, a three-digit NACE code is available for each firm as well as a four-digit regional code identifying one of 86 counties. Employment figures are recomputed on an eight-hour-day basis. For estimation purposes, output is defined as revenue from production plus the change in inventories of the firm's production, both deflated by industry-specific PPI. Capital is defined as tangible and intangible fixed assets, deflated by CPI. Finally, material is defined here as the cost of production of goods sold, deflated by industry-specific PPI.

[10] Firms with NACE codes in the range of 150-366 are considered to be manufacturing firms for the purpose of this study.

Basic firm characteristics with an emphasis on the differences between exporters and non-exporters are reported in Table 1. In the sample, 86% of manufacturers export in 1997 as well as in 2002. Exporters are substantially bigger than non-exporters both in terms of sales and employment. While exporters paid roughly the same wages as non-exporters in 1997, the wage gap widened in favor of exporters' employees over the six years.

Although the relative number of exporters and non-exporters is almost the same at the beginning and at the end of the observed period, the transition between exporting and non-exporting is sizeable. Out of the total 1796 firms, 372 firms changed status from exporting to non-exporting or vice versa at least once over the period 1997-2002. A detailed distribution of exporting patterns is listed in Table 2. Figure 1 shows the number of firms entering and exiting export every year. Entering and exiting firms are on average smaller than all firms in the sample (with the average number of employees at 206 and 126, respectively, compared to the sample average of 374). Firms owned by a domestic private owner prevail among entering and exiting firms with approximately a 66% share, compared to a 56% share in the whole sample. Details are provided in Table 3.

5.2 Exchange rates

When monetary separation took effect in the former Czechoslovakia in February 1993, the Czech koruna remained pegged to the currency basket of four European currencies and the American dollar.[11] Three months later, the band width was set to ±0.5% and the composition of the basket was narrowed to two currencies only, the Deutsche mark and the American dollar.[12] The band was widened to ±7.5% in February 1996. After a period of strong depreciation and decrease in the foreign exchange reserves held by the central bank, the bank in agreement with the government decided to replace the currency basket with a floating regime. The

[11] The weights of the currencies were the following: USD: 49.07%, DEM 36.15%, ATS 8.07%, FRF 2.92%, CHF 3.79%

[12] The weights of the currencies were the following: DEM 65% , USD 35%.

managed float was adopted on May 27, 1997, with the Deutsche mark (and later the euro[13]) as a reference currency.

From that time, the activity of the central bank on the foreign exchange market has been limited. Except for two interventions in 1998 and 2000 and a series of interventions in 2002 when the central bank attempted to slow down the pace of appreciation, monthly foreign exchange trading of the central bank typically amounted to less than USD 100 million during 1997-2004.[14] In comparison to the average daily market turnover of more than USD 2900[15] million during the same period, the influence of the central bank is negligible.

The Czech currency experienced two episodes of strong depreciation against its reference currency between 1997-2004. In 1997, the koruna depreciated by more than 16% in three months, resulting in an end-of-year depreciation of 9.8%. In 1999, a decline of more than 10% in three months ended at a benign 2.6% end-of-year figure. On the other hand, the most pronounced appreciation occurred at the end of 2001 and in 2002, when the currency gained more than 15% over ten months until the central bank and government announced measures to be taken against sharp appreciation. Among others, measures included the transfer of future privatization proceeds directly into the foreign exchange reserves of the central bank (so that market rates were not influenced).

To test hypotheses on the influence of exchange rate level and volatility, industry-specific exchange rates were constructed, in two datasets were combined. Bilateral exchange rates for the Czech currency and currencies of its 26 main trading partners come from the database of the Czech National Bank. Detailed data on bilateral trade at the 3-digit SITC level were provided by the Ministry of Industry and Trade of the Czech Republic. Having SITC categories linked to NACE industry codes, industry-specific exchange rates for each industry were constructed as the weighted average of exchange rate indexes with the weights based on the relative importance of export destinations. Average yearly exchange rates were used to compute the index of

[13] The fixed parity is EUR 1 = DEM 1.95583.
[14] Source: www.cnb.cz.
[15] Source: www.cnb.cz and author's calculations.

industry-specific exchange rate level (variable *iser*), while daily exchange rates were used to compute the index of industry-specific exchange rate volatility (variable *isvolatility*). An increase in *iser* indicates depreciation of the Czech currency, and an increase in *isvolatility* indicates an increase in the volatility of the exchange rate. The index of industry-specific exchange rate level is equal to one in the year 1997. Figure 2 documents inter-industry differences in the evolution of industry-specific exchange rates.[16]

6 Empirical Results

The probability that a firm exports is estimated here. The focus is on three areas: the importance of sunk costs for firms owned by domestic and foreign owners, different reactions to exchange rate movements and production of spillovers that influence the exporting decisions of other firms.

6.1 Sunk costs

Table 4 reports estimation results for the basic specification, i.e., modeling the decision to export on the lagged exporting status, industry-specific exchange rate, firm size (represented by number of employees), average wage, investments and ownership dummies. The number of employees is recomputed on an eight-hour-day basis, wages are in logs, and investments enter as a ratio of intangible investments over sales. All three variables are lagged one year. In addition, year and industry dummies are included where applicable.

Since the estimation of the coefficient on the lagged exporting status involves several complications, I proceed in four steps. First, the linear probability model estimation should provide an upper bound on the coefficient on the lagged exporting status since it captures all unobserved firm-specific effects that influence participation in exporting and are likely to be highly serially correlated. On the contrary, the fixed-

[16] Note that the evolution of industry-specific exchange rate is plotted for 2-digit NACE industries in Figure 2, although more precise 3-digit industry differentiation is used for the estimation.

effects estimation is assumed to result in a downward bias in the coefficient on the lagged exporting status. To address the problem of serial correlation in unobserved firm-specific effects, the first differences Arellano-Bond GMM estimator is employed as a preferred specification. Finally, the results of probit estimation are reported.

In all four specifications, the sunk costs of entering foreign markets appear to be huge. OLS and probit coefficients on the lagged exporting status suggest that exporting experience from the previous year increases the probability of exporting by 71% and 65%, respectively. While this is considered to be an upper bound for the coefficient on the lagged exporting status, the estimate of fixed-effects specification gave a lower bound of 16%. The preferred first differences GMM estimator indicates that exporting in one year increases the probability of exporting in the next year by 43%.

In a search for differences in sunk costs across different ownership types, specifications involving interactions between lagged exporting status and ownership types were estimated. Although negative signs of the coefficients are in line with the expectation that sunk costs of firms with foreign and international ownership are lower than sunk costs of firms with a domestic owner, coefficients are insignificant across all estimation methods (estimation results are not reported in this draft).

Estimates of other coefficients from Table 4 suggest that bigger firms and firms paying higher wages are more likely to export. Foreign-owned firms, firms with international ownership, and firms with domestic mixed ownership are also more likely to export than other domestic firms.

6.2 Exchange rates and foreign owners

To assess the role of exchange rate level and volatility in a firm's decision to export, four specifications are estimated and summarized in Table 5. To reflect the possibility that it may take some time for a firm to react to exchange rate changes (due to lasting contracts or sluggish adjustment of production), both industry-specific level and industry-specific volatility variables are included with no lag and with the lag of one year. For the level of exchange rate, specifications (1) and (2) suggest that the current exchange rate level is more important than the lagged one, in terms of significance as well as magnitude. The signs are in line with expectations: depreciation (increase in *iser*) increases the probability of exporting substantially (10% depreciation increases the probability by roughly 4%). Changes in exchange rate levels exert greater influence on domestic firms than on firms with either foreign or international ownership. With foreign owners, the interaction coefficient is significant and reduces the effect of exchange rate level changes to half compared to domestically-owned firms. Reactions of exporting status to changes in exchange rate level lagged by one year are smaller, and differences between different ownership types play no or marginal role.

Results are not that intuitive in the case of the effects of changes in exchange rate volatility. Coefficients obtained from specification (3) in Table 5 show, in line with the theory, that higher volatility significantly decreases the probability of exporting for foreign-owned and internationally-owned firms. Similar results, albeit with a smaller magnitude, are estimated using specification (4). One should be cautious, however, when drawing conclusions from the results above due to the relatively high correlation between lagged volatility and exchange rate level either lagged or with no lags (66% and 47%, respectively).

6.3 Spillovers

To assess the role of spillovers in exporting, the following specifications have been considered. First, spillovers influencing the exporting status of other firms are assumed to be produced either by firms with foreign or international ownership, or by exporting firms. The rationale for spillovers produced by firms controlled by a foreign owner stems mainly from the migration of employees possessing the knowledge of foreign markets from multinational corporations to domestic firms. On the other hand, the rationale for spillovers produced by exporting firms assumes, in addition to migration, that the existing infrastructure used by exporters (e.g., transport networks) is accessible to other firms and facilitates their entry into foreign markets.

Second, spillovers can occur within a group of firms, where group can be defined as an industry, county, region, industry and county, or industry and region.[17] Concentration of foreign-owned firms in the group is computed for each firm either as the number of foreign-owned firms over the number of all firms or as the sum of revenues of foreign-owned firms over the sum of revenues of all firms in the group. Concentration of exporters is computed either as the number of exporting firms over the number of all firms or as the sum of exports over the sum of revenues of all firms in the group. The firm whose concentration is computed is obviously not included in the computation.

The probability of exporting is then estimated using the basic model with concentration entering the right side of the equation either without any lag or with the lag of one year, to reflect the time needed to begin exporting. To control for geographic, industry-specific and time-specific differences as well as for ownership, appropriate dummies are included (county or region dummies for geographic differences, 2- or 3-digit industry dummies, year and ownership dummies).

Assuming that the presence of exporting firms could increase other firms' probability of exporting, coefficients for the concentrations are expected to be positive. However, coefficients in actual estimations are in most cases negative. Table 7 shows the spillovers from the presence of exporters on the exporting status of firms with a domestic owner. A coefficient at the ratio of the number of exporters and the number of all firms in the group is negative and significant in the case of four groups: county, 2-digit industry, 3-digit industry, and combination of a region and 3-digit industry. The pattern of results does not change meaningfully even if all firms (not only domestic) are included in the estimation. In the specification without any lag for concentration measures (Table 6), two coefficients based on the revenues and exports, instead of the number of firms, become significant and positive.[18]

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[17] Throughout the text, I use the term "firm-level" to refer to units with a unique Standard Identification Number (ICO). If a firm has several plants operating in different locations, only the location of the headquarters appears in the data. This creates problems with controlling for regional differences since there is no information about actual plant location.

[18] If lagged concentration measures are relevant and are omitted, the estimated coefficients are biased.

Although negative spillovers are surprising, they are in line with two other studies focused on exporting spillovers. Bernard and Jensen (2004) report that all spillover measures except one have negative coefficients. In the two-stage probit estimation of Aitken, Hanson and Harrison (1997), coefficients on local export concentration are negative in all four considered specifications and significant in two of them. The issue of negative spillovers thus deserves further attention.

Tables 8 and 9 include the results of the estimation of spillovers produced by multinationals and influencing the exporting status of domestic firms within a group. In this case, most of the significant coefficients are negative again, suggesting that proximity to a multinational has negative influence on a firm's decision to export.

Conclusion

Estimation on the sample of Czech firms confirms the results of previous studies that the sunk costs of exporting are large and significant. However, no significant differences are found between sunk costs incurred by domestic and foreign firms. On the contrary, domestic and foreign firms differ significantly only in their responsiveness to exchange rate changes. The probability of a domestic firm exporting is twice more sensitive to changes in the exchange rate level than the probability of exporting in the case of a similar foreign-owned firm. Exchange rate volatility, in line with expectations, negatively influences the exporting decision of a firm. In the search for spillovers, the results are mixed. Proximity to an exporting firm (either in geographic or sectoral terms) has, surprisingly, a negative effect on the decision of a firm to export in most of the specifications.

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Appendix

Table 1
Firm characteristics (continuing sample, 1997-2002)

	Number of firms		Average Employment[a]		Average Sales[b]		Average Wages[b,c]	
	1997	2002	1997	2002	1997	2002	1997	2002
All	1796		396	337	540869	607799	127.66	141.74
Exporters (% of all)	86%	86%	109%	112%	110%	112%	100%	101%
Non-Exporters (% of all)	14%	14%	42%	36%	37%	26%	100%	92%

Notes: [a] Recomputed on an eight hour day basis
[b] Thousands of CZK, constant prices of 1997
[c] Annual wage

Table 2
Patterns of Transitions Between Exporting and Non-Exporting
(total number of firms in the continuing sample: 1796)

Percentage of firms	Pattern	Percentage of firms	Pattern	Percentage of firms	Pattern
75.17%	111111	0.39%	.11...	0.11%	.1.1..
4.12%	......	0.33%	...1..	0.11%	.1.111
2.67%	11111.	0.33%	1..111	0.11%	.11..1
1.84%	.11111	0.28%	.111.1	0.11%	1....1
1.50%	..1111	0.28%	.1111.	0.11%	1..11.
1.34%	1.1111	0.28%	111..1	0.11%	1.1...
1.17%	1111..	0.22%	.1....	0.11%	11.1..
0.95%	111...	0.22%	1.11..	0.11%	11.11.
0.89%	..11..	0.22%	11....	0.06%	...11.
0.84%	1.....	0.22%	111.1.	0.06%	..1.1.
0.72%	11	0.17%	....1.	0.06%	..1.11
0.67%	1	0.17%	..111.	0.06%	.1..11
0.67%	...111	0.17%	.111..	0.06%	1..1..
0.61%	..1...	0.17%	1...11	0.06%	1..1.1
0.61%	11.111	0.17%	11..11	0.06%	1.1..1
0.50%	111.11	0.11%	..1..1	0.06%	1.1.11
0.50%	1111.1	0.11%	..11.1	0.06%	1.11.1

Table 3
Characteristics of Firms Entering and Exiting Export Market

	Ownership					Average Employment[a]
	Domestic Private	Domestic State	Domestic Mixed	Foreign	International	
Entering Firms	66%	2%	8%	12%	11%	206
Exiting Firms	66%	3%	10%	10%	12%	126
All Firms	56%	3%	12%	13%	16%	374

Notes: [a] Recomputed on an eight hour day basis

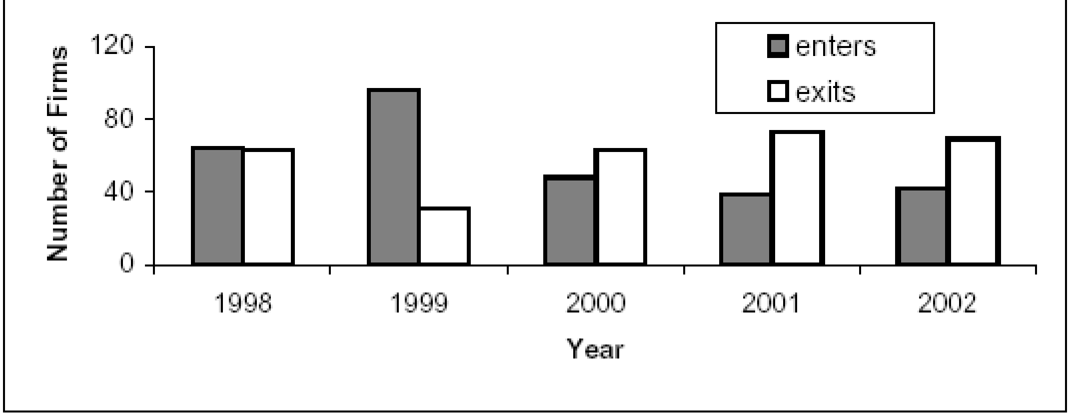

Figure 1: **Entering and Exiting Export Market**

Figure 2: Evolution of industry-specific exchange rate (plots based on 2-digit NACE aggregation)

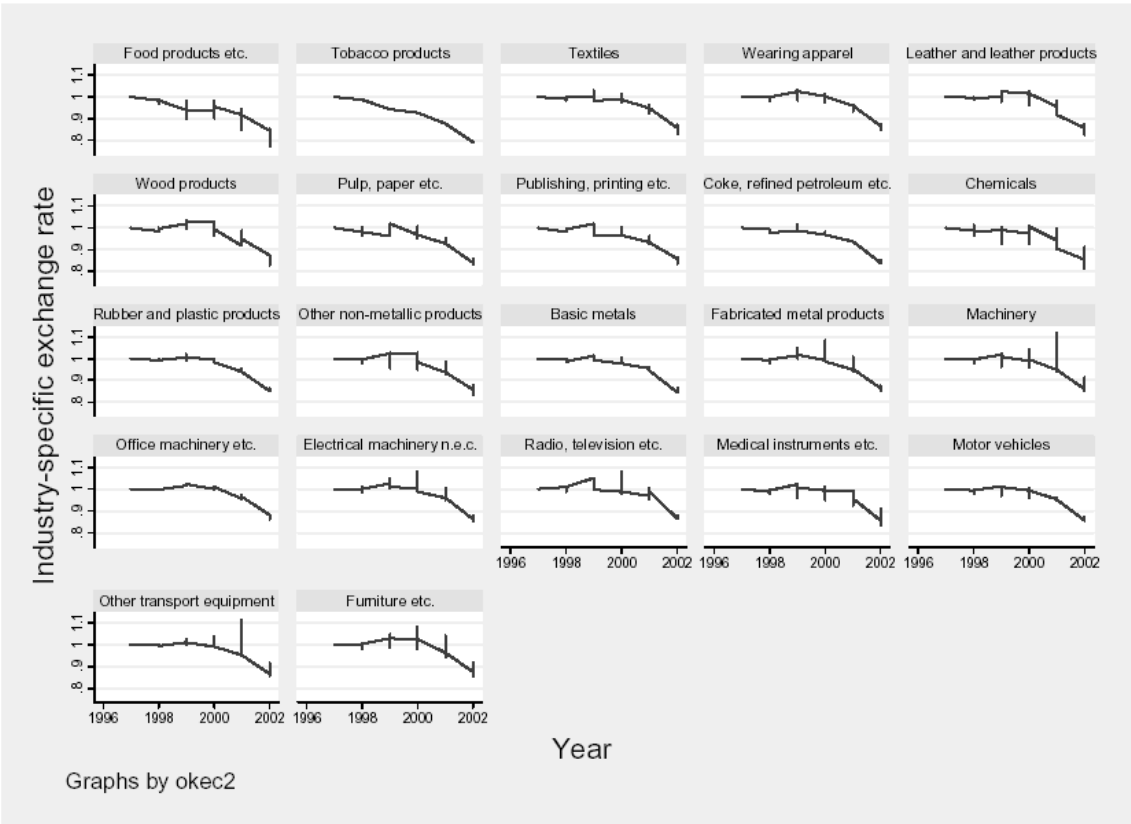

Table 4: **The decision to export** (dependent variable: export status)

	OLS	Fixed Effects	Probit	GMM (1st differences)
Lagged export status	0.71355 ***	0.16023 ***	0.65481 ***	0.43476 ***
	(.01504)	(.03209)	(.01996)	(.05489)
Industry Specific Exchange Rate	0.37799 **	0.29460	0.37622 **	0.26352
	(.16044)	(.20444)	(.15656)	(.22621)
Employment	6.6E-06 ***	3.9E-05 **	5.5E-05 ***	9.4E-06
	(1.7E-06)	(1.6E-05)	(1.1E-05)	(2.4E-05)
Wages	0.03704 ***	0.00264	0.02948 ***	0.00319
	(.01155)	(.03812)	(.01055)	(.05205)
Investments	0.32980	0.32601	0.14556	0.48724
	(.2858)	(.26555)	(.2947)	(.48407)
Ownership: Foreign	0.01926 ***	0.03620	0.02336 ***	0.02326
	(.00708)	(.02883)	(.0068)	(.03016)
Ownership: International	0.01711 **	0.01577 *	0.00701	0.03463 *
	(.00683)	(1.73)	(.00724)	(.01814)
Ownership: Domestic Mixed	0.01826 ***	0.01728	0.00848	0.02979
	(.00696)	(.01654)	(.00763)	(.02353)
Year Dummies	Included	Included	Included	Included
Industry Dummies	Included		Included	
Number of observations	8044	8044	8016	6302

Notes:

Employment is in logs, all firm characteristics are lagged one year.
Robust standard errors in parentheses.
Marginal effects reported for probit estimation.
* Significant at 10% level
** Significant at 5% level
*** Significant at 1% level

Table 5: **Responsiveness to Changes in Exchange Rates Levels and Volatility**
(dependent variable: export status)

	(1)	(2)	(3)	(4)
Lagged export status	0.71307 ***	0.71403 ***	0.71327 ***	0.71280 ***
	(.01506)	(.01499)	(.01504)	(.01505)
Industry Specific Exchange Rate (ISER)	0.42534 ***		0.25713	0.31328 *
	(.16416)		(.21658)	(.18583)
ISER: Foreign	-0.21922 **			
	(.09755)			
ISER: International	-0.11870			
	(.11675)			
ISER: Domestic Mixed	-0.02103			
	(.13591)			
Lagged ISER		0.12467		
		(.16442)		
Lagged ISER: Foreign		-0.00665		
		(.02391)		
Lagged ISER: International		-0.03537 ***		
		(.01513)		
Lagged ISER: Domestic Mixed		-0.01920		
		(.02018)		
ISER Volatility			27.02213	
			(19.77038)	
ISER Volatility: Foreign			-36.64331 ***	
			(13.74467)	
ISER Volatility: International			-35.77365 ***	
			(13.51732)	
ISER Volatility: Domestic Mixed			-18.31022	
			(12.89934)	
Lagged ISER Volatility				17.42683
				(15.93879)
Lagged ISER Volatility: Foreign				-15.82695 **
				(7.76907)
Lagged ISER Volatility: International				-19.05318 ***
				(5.94487)
Lagged ISER Volatility: Domestic Mixed				-9.11293
				(6.31267)
Employment	6.4E-06	7.0E-06 ***	6.5E-06 ***	6.5E-06 ***
	(1.6E-06)	(1.7E-06)	(1.6E-06)	(1.6E-06)
Wages	0.03609 ***	0.03684 ***	0.03490 ***	0.03736 ***
	(.01155)	(.01156)	(.01156)	(.01161)
Investments	0.32506	0.34573	0.31449	0.31855
	(.28681)	(.28545)	(.28633)	(.28668)
Ownership: Foreign	0.22886 **	0.02751	0.08894 ***	0.05128 ***
	(.09398)	(.02353)	(.02695)	(.01671)
Ownership: International	0.13105	0.04795 ***	0.08466 ***	0.05153 ***
	(.11286)	(.01497)	(.02569)	(.01273)
Ownership: Domestic Mixed	0.03855	0.03447 *	0.05335 **	0.03706 **
	(.13332)	(.02097)	(.0269)	(.01584)
Year Dummies	Included	Included	Included	Included
Industry Dummies	Included	Included	Included	Included
Number of observations	8044	8046	8044	7991

Notes: Employment is in logs, all firm characteristics are lagged one year
OLS estimation, robust standard errors in parentheses
* Significant at 10% level
** Significant at 5% level
*** Significant at 1% level

Table 6: **Spillovers from the presence of exporters on exporting status of domestic firms within a group, no lag** (coefficients at the concentration measures, each coefficient from a separate regression)

Group	Concentration measure	
	Number of exporters / Number of all	Export of all / Revenue of all
County	-1.4459 ***	0.2550 *
Region	-1.2050 ***	-0.1574
Industry (2 digits)	-0.4647 ***	-0.0349
Industry (3 digits)	-0.3607 ***	-0.0003
County&Industry (2 digits)	-0.0196	-0.0182
Region&Industry (2 digits)	-0.0609	0.0584 *
County&Industry (3 digits)	-0.0317	-0.0095
Region&Industry (3 digits)	-0.0613 **	0.0017

Notes: OLS estimations with export status as a dependent variable. Explanatory variables include concentration measure, lagged export status, industry-specific exchange rate, lagged number of employees, lagged average wage, lagged intangible investments, dummies for years, ownership, county or region and industry (2- or 3-digits).

* Significant at 10% level

** Significant at 5% level

*** Significant at 1% level

Table 7: **Spillovers from the presence of exporters on exporting status of domestic firms within a group, 1 year lag** (coefficients at the concentration measures, each coefficient from a separate regression)

Group	Concentration measure	
	Number of exporters / Number of all	Export of all / Revenue of all
County	-0.5680 ***	0.0118
Region	-0.2599	0.1131
Industry (2 digits)	-0.3884 ***	0.0091
Industry (3 digits)	-0.2530 ***	-0.0068
County&Industry (2 digits)	0.0074	0.0081
Region&Industry (2 digits)	-0.0533	0.0252
County&Industry (3 digits)	0.0148	0.0185
Region&Industry (3 digits)	-0.0550 **	0.0143

Notes: OLS estimations with export status as a dependent variable. Explanatory variables include lagged concentration measure, lagged export status, industry-specific exchange rate, lagged number of employees, lagged average wage, lagged intangible investments, dummies for years, ownership, county or region and industry (2- or 3-digits).

* Significant at 10% level

** Significant at 5% level

*** Significant at 1% level

Table 8: **Spillovers from the presence of multinationals on the exporting status of domestic firms within a group, no lag** (coefficients at the concentration measures, each coefficient from a separate regression)

Group	Concentration measure: Number of foreign / Number of all		Number of foreign and international / Number of all		Revenue of foreign / Revenue of all		Revenue of foreign and international / Revenue of all	
County	0.2004		0.1382		0.1354		0.0750	
Region	0.2553		-0.3553		0.0948		-0.1276	*
Industry (2 digits)	-0.7101	***	0.0772		-0.0787	*	0.0332	
Industry (3 digits)	-0.1292		0.0265		-0.0540	**	-0.0254	
County&Industry (2 digits)	-0.0063		0.0016		-0.0223		-0.0262	
Region&Industry (2 digits)	-0.0136		0.0096		0.0112		0.0117	
County&Industry (3 digits)	-0.0491		-0.0097		-0.0601	*	-0.0269	
Region&Industry (3 digits)	-0.0334		-0.0132		-0.0075		-0.0020	

Notes: OLS estimations with export status as a dependent variable. Explanatory variables include concentration measure, lagged export status, industry-specific exchange rate, lagged number of employees, lagged average wage, lagged intangible investments, dummies for years, ownership, county or region and industry (2- or 3-digits).

Table 9: **Spillovers from the presence of multinationals on the exporting status of domestic firms within a group, one year lag** (coefficients at the concentration measures, each coefficient from a separate regression)

Group	Concentration measure: Number of foreign / Number of all		Number of foreign and international / Number of all		Revenue of foreign / Revenue of all		Revenue of foreign and international / Revenue of all	
County	-0.0465		-0.0529		-0.0656		-0.0577	
Region	0.1541		-0.2955		0.1672		-0.0147	
Industry (2 digits)	-0.7570	***	-0.0041		-0.0184		-0.0011	
Industry (3 digits)	0.0449		0.0760		-0.0007		0.0078	
County&Industry (2 digits)	0.0271		0.0017		0.0258		0.0035	
Region&Industry (2 digits)	-0.0172		0.0115		0.0033		-0.0058	
County&Industry (3 digits)	0.0420		0.0585	*	-0.0058		0.0285	
Region&Industry (3 digits)	-0.0234		-0.0233		0.0009		-0.0041	

Notes: OLS estimations with export status as a dependent variable. Explanatory variables include lagged concentration measure, lagged export status, industry-specific exchange rate, lagged number of employees, lagged average wage, lagged intangible investments, dummies for years, ownership, county or region and industry (2- or 3-digits).

Inflation Persistence in New EU Member States: Is It Different Than in the Euro Area Members?[1]

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Abstract

Is inflation persistence in the new EU Member States (NMS) comparable to that in the euro area countries? We argue that persistence may not be as different between the two country groups as one might expect. We confirm that one should work carefully with the usual estimation methods when analyzing the NMS, given the scope of the convergence process they went through. We show that due to frequent breaks in inflation time series in the NMS, parametric statistical measures assuming a constant mean deliver substantially higher persistence estimates for the NMS than for the euro area countries. Employing a time-varying mean leads to the reversal of this result and suggests similar or lower inflation persistence for the NMS compared to euro area countries. Structural measures show that backward-looking behavior may be a more important component in explaining inflation dynamics in the NMS than in the euro area countries.

JEL Classification: E31, C22, C11, C32;

Keywords: Inflation persistence, new Member States, time-varying mean, New Hybrid Phillips Curve

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1. Introduction

In this paper, we provide input into the discussion concerning the readiness of the new EU Member States (NMS) to adopt the euro. With regards to euro adoption, the NMS face two closely related challenges. First, they need to fulfill the Maastricht criteria, including the one on inflation. Second, they need to adapt their economies to live with the euro. Inflation persistence differences between the euro area countries and the NMS can represent an obstacle to dealing successfully with both challenges.

The issue of differences in inflation persistence was raised by various studies[4] in reaction to inflation divergence among the euro area members. These studies show that the inflation convergence reached prior to adopting the euro has not been sustained among the current euro area members since 1998, and they point out that inflation persistence is one of the most prominent reasons. The euro adoption candidates therefore need to learn what their national inflation persistence is and, if it is high, try to reduce it in order to prevent inflation from exceeding the euro area average after euro adoption. Specifically, high estimates of inflation persistence may call for institutional and labor market reforms that typically improve the flexibility of the domestic economy and subsequently reduce inflation persistence.

Furthermore, inflation persistence can influence the fulfillment of the Maastricht criteria, which is an issue for the NMS before and even after euro adoption. High inflation persistence corresponds to the slow return of inflation to its long-run value after a shock (e.g., an oil shock) occurs. Therefore, NMS with high estimates of persistence could struggle to meet the inflation criterion should a common shock hit the European countries. They could struggle for two reasons. First, it would take them longer to combat the consequences of this common shock and reduce inflation to its long-run value. This decreases the probability of meeting the inflation criterion. Second, the Maastricht criterion on inflation stability says that the NMS must have inflation comparable to the best inflation performers. This inherently implies that in the case of common shocks, the benchmark will be set by countries with a high speed of inflation adjustment. If differences in national inflation persistence values across the EU are large, it will be very difficult to stay close to the benchmark for the NMS

[4] Section 2 provides a literature overview of papers related to inflation persistence in this context.

with relatively high persistence. It is therefore of crucial importance to have estimates of inflation persistence available for the NMS prior to euro adoption.

To our knowledge, there are only a few studies assessing inflation persistence in the NMS. The available results, mainly based on micro data, indicate that inflation persistence in the NMS could be higher than in the current euro area members, although in some countries it is decreasing slowly over time. Since disaggregate evidence makes international comparison problematic, we carry out our analysis using inflation aggregates.[5] On the other hand, inflation aggregates can suffer from an aggregation bias, i.e., inflation aggregates exhibit higher persistence than the particular components included.

In this paper, we use several approaches to define and estimate inflation persistence in order to discuss thoroughly the appropriateness of various measures for the measurement of inflation persistence in the NMS. Furthermore, we attempt to choose the measure that enables international comparison of the euro area countries and the NMS. The list of the inflation persistence measures employed in this study is depicted by the following scheme:

Scheme of inflation persistence measures considered

Statistical measures – Parametric	i) Autoregressive model with constant mean (naïve estimates)
	ii) Autoregressive model with time-varying mean
	iii) Autoregressive fractionally integrated moving average model (ARFIMA)
Structural measures	iv) Estimates of the New Hybrid Phillips Curve (NHPC)

First of all we adopt a purely statistical approach and estimate several parametric measures based on the sum of the autoregressive coefficients and impulse response functions, before employing a structural approach that provides an estimate of inflation inertia based on structural parameters. These approaches have already been applied to the analysis of inflation persistence in the current euro area members. Hence, we can compare our results for this control group with those of previously published work.

[5] Aggregates are also relevant for conducting monetary policy.

The first group of parametric statistical measures of inflation persistence assumes a constant mean. The four NMS[6] in our sample score highly among the EU members as far as inflation persistence is concerned. The estimated inflation persistence for the NMS is close to one, once the confidence intervals have been taken into account. This finding is in line with the available micro studies on inflation persistence in the NMS and with previously published research on inflation persistence in the current euro area Member States.

Our second, more sophisticated, statistical measure of inflation persistence gives, however, another picture. It allows for a time-varying mean. We separate the impact of persistence in nominal contracts and persistence in the real economy factors influencing inflation (intrinsic and extrinsic persistence) from the impact of inflation expectations and monetary policy regime changes (the two being inseparable in our model). We find that according to this measure the estimates of inflation persistence in the NMS are comparable to those in the current euro area members.

In our third statistical measure, we focus on the measure that is built on the autoregressive fractionally integrated moving average (ARFIMA) representation of the inflation process. A stationary process with parameter instability and a fractionally integrated process can look very similar to each other (mean reversion). Nevertheless, the implications of the two representations of the inflation process for the measurement of inflation persistence differ. Values of the impulse response function based on ARFIMA suggest that persistence in some NMS is higher than in the rest of the sample. Additional statistical tests suggest that assuming a stationary process with breaks is a preferable assumption to fractionally integrated models for almost all the countries considered.

The various statistical measures of inflation persistence introduced so far provide a complex picture of the actual extent of inflation inertia in the NMS compared to the euro area. It is worth noting that these measures can mainly serve as inputs to the debate about the fulfillment of the Maastricht criteria. If the values are comparable for the two groups of countries (the euro area countries and the NMS), it could be less difficult for the NMS to fulfill the Maastricht criterion on inflation, for example.

[6] In our analysis, the NMS are represented by four countries (the Czech Republic, Hungary, Poland, and Slovakia) since for these four NMS the complete data needed for the inflation persistence analysis are available.

However, these measures cannot serve as a basis for inferences about the country-specific effects of common monetary policy in the euro area extended to the NMS. The argument draws on the Lucas critique, which views structural (deep) parameters as the only appropriate measure underlying the discussion on the consequences of unequal inflation persistence after the monetary policy regime switch.

Therefore, as a last approach to measuring inflation persistence, we introduce a model based on deep parameters that allows an international comparison of the extent of inflation inertia. We estimate the hybrid version of the new Phillips curve (NHPC) for the Czech Republic, Poland, and Slovakia, and we compare the estimation results with existing studies for Hungary and the euro area. The structural measure suggests that the influence of expected future inflation on current inflation does not predominate over the influence of past inflation in the Czech Republic and Hungary.

The structure of the paper is as follows. Section 2 reviews the available literature on the topic, placing special emphasis on the relevance of inflation persistence in the NMS. Section 3 describes the approaches adopted to measuring and estimating inflation persistence. Section 4 reports on and discusses the results of these alternative estimates. Section 5 concludes.

2. Related literature

Inflation persistence is a crucial aspect of overall inflation dynamics. It is, therefore, important to compare the size of inflation persistence between countries, especially if they form a monetary union. For example, differences in inflation persistence among the euro area countries are blamed for the persisting inflation differentials in the euro area. Angeloni and Ehrmann (2007) set up an empirical model consisting of 12 countries that share the same nominal interest rate. Simulations based on the model estimated on quarterly panel data covering 1998–2003 suggest the relevance of differences in inflation persistence for preserving inflation differentials as well as other cyclical differentials.

Furthermore, the ECB targets price stability in the euro area as a whole, and the same nominal interest rate is prescribed for countries that can experience different levels of inflation and inflation persistence. Bjorksten (2002) and Ca'Zorzi and De Santis (2003) notice that inflation differences may prevail longer inside the euro area once the NMS introduce the euro. In order to avoid divergence, EC (2002, 2004), ECB (2003), OECD (2002), and IMF (2002) suggest that adequate national structural reforms should be adopted in countries with high inflation persistence.

Inflation persistence measures are usually based on univariate models (e.g., the sum of autoregressive coefficients, the largest autoregressive root, half-life and spectral density at frequency zero – see Marques (2004) for a summary). In univariate analysis, the mean of the inflation process is often assumed to be constant. However, some recent studies examine several economic reasons that question this assumption. First, Bilke (2005) and Dossche and Everaert (2005) discuss the role of monetary policy changes for the inflation mean. Second, Gadzinski and Orlandi (2004) and Levin and Piger (2004) focus on the influence of administrative price changes on the mean of inflation. In this paper we argue that the specific situation of the NMS (e.g., monetary policy regime change, administrative price regulation) can also have an impact on the mean of inflation and should be taken into account when measuring inflation persistence.

Not accounting for breaks in the inflation mean causes bias of inflation persistence measures (as shown for the autoregressive process by Perron, 1989). Some recent empirical studies have approached this problem by allowing for structural breaks in inflation series. Levin and Piger (2004) estimate an autoregressive model for several industrial countries during the period 1984–2003, first with the assumption of a constant mean, and subsequently allowing for one structural break in the mean of inflation. Cecchetti and Debelle (2006) go further and estimate inflation persistence allowing for no break or one, two or three breaks. These studies find evidence for structural breaks and demonstrate that accounting for breaks reduces the inflation persistence estimates.

Marques (2004) stresses that it is more natural to assume a time-varying mean of inflation than to assume a constant mean or to search for breaks in the mean of inflation. In his analysis of US and euro area inflation, Marques considers several treatments for the mean of inflation, including the application of the Hodrick-

Prescott's (1997) filter and a moving average. In general, his results confirm that more flexibility assumed for the mean of inflation delivers lower estimates of persistence. Similar results for the US and the euro area are provided by Dossche and Everaert (2005), who model the time-varying mean as an AR(2) process. Benati (2006), in the framework of AR(p) representation of inflation series for 21 countries, allows for random-walk time-varying parameters. Finally, Darvas and Varga (2007) use time-varying coefficient autoregressive models to investigate Hungarian inflation persistence.

The structural estimates describing inflation dynamics are based on the New Hybrid Phillips Curve introduced by Galí and Gertler (1999). The authors estimate the NHPC on US quarterly data for the period 1960:1–1997:4 and find that forward-looking behavior predominates in comparison with backward-looking behavior. Galí, Gertler, and López-Salido (2001) extend the framework laid down in Galí and Gertler (1999) for the euro area. They consider the period 1970:1–1998:2, and their estimation results suggest backward-looking price setting behavior is even less important in the euro area than in the US.

Both studies use the generalized methods of moments (GMM) approach to estimate the NHPC. The use of GMM, however, has been much criticized for several reasons. The issue of weak instruments is addressed, for example, in Ma (2002). Zhang et al. (2006) also argue that the presence of serial correlation in errors influences the validity of lagged values of inflation and the real variables as instruments. Zhang et al. (2006) estimate the NHPC for US quarterly data for the period 1960:1–2005:1, and question the robustness of the results in Galí and Gertler (1999) regarding the instrument set employed. In this paper, we employ instrument sets from all the studies mentioned.

Most of the available research on inflation persistence in the NMS is based on micro data. Micro analysis is available for the Czech Republic, Hungary, Poland, and Slovakia in Babetskii, Coricelli, and Horváth (2006), Ratfai (2006), Konieczny and Skrzypacz (2005), and Coricelli and Horváth (2006), respectively. Some of the results signal that high inflation persistence can indeed be a problem for some NMS. Two studies that draw on macroeconomic aggregates are Darvas and Varga (2007) and

Lendvai (2005). These studies focus on Hungary. Lendvai (2005) estimates a structural Phillips curve for quarterly data covering the period 1995:1–2004:1.The results suggest that inflation exhibits higher inflation inertia in Hungary than in the euro area.

3. Stylized facts and models for measuring inflation persistence

In this section we introduce various approaches to measuring inflation persistence. We start with naïve estimates that assume a constant mean of inflation, then move on to models that relax the constant mean assumption. We also discuss ARFIMA models. Finally, we focus on the estimation of the New Hybrid Phillips Curve (NHPC).

The literature provides several definitions of inflation persistence.[7] We stick to the usual approach that relates inflation persistence to the speed at which inflation converges to its equilibrium value after a shock. Intuitively, inflation persistence is high if the inflation series does not frequently oscillate around its mean.[8] So, simple visual inspection of inflation plots for various countries (see Appendix 3) provides the first idea about the persistence of inflation in the euro area countries and the NMS. In addition, Table 1 reports the number of times that inflation series switched from above to below their means and vice versa.

Table 1: Number of crosses of inflation means.

Period	Czech Rep.	Hungary	Poland	Slovakia	EU12
1993:2–2006:1	11	25	11	16	19
2001:1–2006:1	6	16	11	11	11
	Belgium	Finland	France	Germany	Greece
1993:2–2006:1	28	18	16	17	19
2001:1–2006:1	16	9	9	13	12
	Ireland	Italy	Netherlands	Portugal	Spain
1993:2–2006:1	27	31	27	29	15
2001:1–2006:1	13	11	11	11	12

Source: Own calculations based on OECD OEO database.

Note: Inflation rates for Hungary available since 1995:1.

[7] See, for example, Batini (2002).

[8] Marques (2004) shows the inverse relationship between inflation persistence and mean reversion when modeling the inflation process as an autoregressive process of order *k*.

Table 1 illustrates an issue that often arises when we employ various approaches to measuring inflation persistence in the NMS. For the whole sample (1993:2–2006:1), the inflation series for the NMS cross their means less frequently than the inflation series for the euro area countries. According to the aforementioned definition, fewer switches indicate higher inflation persistence for the NMS compared to the current euro area members. However, this is not necessarily so, since the NMS went through a transformation period, during which high initial values of inflation led to high means of inflation. Moreover, price levels in the NMS have been converging to those of the euro area members. Both factors – transformation as well as convergence – may weaken the link between persistence and the frequency of mean crosses. We indeed observe that once we restrict the sample to the period 2001:1–2006:1, the number of crosses for the NMS and euro area members is comparable (see Table 1).

Going back to the definition of inflation persistence, the focus is on the concept of the equilibrium value of inflation. Some measures of persistence introduced in the following paragraphs view the equilibrium value from a long-run perspective, while others focus rather on the medium run.[9] Table 1 implies that the appropriateness of the various measures of persistence for the NMS arises from their ability to take into account specific attributes of inflation processes in the NMS.

3.1 Statistical measures – parametric (autoregressive models)

(i) Constant mean (naïve estimate)

The most widely used measure of persistence across the literature, the sum of autoregressive coefficients, is based on the assumption that inflation follows a stationary autoregressive process of order *K*:

$$\pi_t = \mu + \sum_{i=1}^{K} \alpha_i \pi_{t-i} + \varepsilon_t . \tag{1}$$

---

[9] We find it useful to distinguish these two time horizons when discussing inflation persistence in the NMS, since long-run and medium-run equilibria may differ in periods of convergence. For a discussion on the importance of time horizons when dealing with the concept of equilibrium, see Driver and Westaway (2005).

The sum of the autoregressive coefficients is then defined as:

$$\rho_K = \sum_{i=1}^{K} \alpha_i \,, \tag{2}$$

where π_t denotes the observed inflation rate at time *t*. We proceed as follows. First, we obtain OLS estimates of $\alpha = [\alpha_{1,\ldots,}\alpha_K]$ for specifications with lag lengths $K = 1,..,5$. The preferred number of lags is then chosen according to the AIC and BIC criteria and the sum of autoregressive coefficients ρ_K is computed in line with (2), i.e., all coefficients, including the insignificant ones, are summed. Second, we apply Hansen's (1999) grid bootstrap procedure[10] to the same data to estimate the median unbiased ρ_K and its 90% confidence intervals, again for lag lengths $K = 1,..,5$. Unlike OLS estimation of the AR(*K*) process, Hansen's (1999) grid bootstrap procedure provides median-unbiased estimates with asymptotically correct confidence intervals.

(ii) Time-varying mean

Angeloni et al. (2006) distinguish three types of inflation persistence. Intrinsic inflation persistence relates to nominal rigidities and to the way wages and prices are set. Extrinsic inflation persistence stems from persistence in the inflation-driving real variables (e.g., the output gap). Finally, expectations-based inflation persistence is driven by differences between public perceptions about the inflation target and the central bank's true (explicit or implicit) inflation target. Dossche and Everaert (2005) set up a model that allows these three sources of inflation persistence to be distinguished. Moreover, their model controls for shifts in the inflation mean caused by monetary policy changes. This approach is relevant for the NMS since it estimates inflation persistence net of expectations-based persistence and persistence related to the effects of monetary policy.

[10] Hansen's (1999) grid bootstrap procedure is used in several recent studies on inflation persistence, e.g., Benati (2006), Levin and Piger (2004), and Gadzinski and Orlandi (2004).

We draw on the model introduced in Dossche and Everaert (2005), who estimate univariate and multivariate time series models. The univariate time series model should put the naïve statistical measures from the previous subsection into a broader perspective since the model enables us to identify the part of inflation persistence that stems from monetary policy actions.

The model Dossche and Everaert (2005) start with has the following form:

$$\pi_{t+1}^{T} = \pi_{t}^{T} + \eta_{1t} \tag{3}$$

$$\pi_{t+1}^{P} = (1-\delta)\pi_{t}^{P} + \delta\pi_{t+1}^{T} + \eta_{2t}, 0 < \delta < 1, \tag{4}$$

$$\pi_{t} = \left(1 - \sum_{i=1}^{4}\varphi_{i}\right)\pi_{t}^{P} + \sum_{i=1}^{4}\varphi_{i}L^{i}\pi_{t} + \beta_{1}z_{t-1} + \varepsilon_{1t}, \sum_{i=1}^{4}\varphi_{i} < 1, \tag{5}$$

where π_{t}^{T} is the central bank's inflation target, π_{t}^{P} is the inflation target as perceived by the public, z_{t} stands for the output gap, and disturbances $\eta_{1t,}\eta_{2t,}\varepsilon_{1t}$ are mutually independent zero-mean white noise processes.

The central bank's inflation target is modeled as a random walk process in equation (3). The model assumes this equation even if the central bank does not target inflation explicitly. Some countries have adopted inflation targeting during the period of interest (e.g., the Czech Republic in 1997/1998). However, we do not impose known targets into the model.

Equation (4) captures the relationship between the central bank's inflation target and the target as perceived by the public.[11] The parameter δ measures the expectations-based persistence – a value close to zero indicates that the public forms its inflation expectations in a backward-looking manner. The effect of a shock to inflation is then

[11] The model equalizes the inflation target as perceived by the public, and public inflation expectations.

prolonged via inflation expectations. On the other hand a parameter value close to one shows that a central bank is highly credible in communicating its inflation target.[12]

Equation (5) takes a form close to the traditional Phillips curve. Private inflation expectations are represented by the perceived inflation target. The sum of the autoregressive coefficients captures the intrinsic inflation persistence.

We make two identifying assumptions. First, we assume in accordance with Dossche and Everaert (2005) that $\beta_1 = 0$.[13] Second, to keep the estimation simple we also adopt the following assumption: $\eta_{2t} = 0$ for all *t*.

If we incorporate these assumptions, the basic version of the model has the following form:

$$\pi_t = \left(1 - \sum_{i=1}^{q} \varphi_i\right)\pi_t^P + \sum_{i=1}^{q} \varphi_i L^i \pi_t + \varepsilon_{1t} \qquad \varepsilon_{1t} \approx N(0, \sigma_\varepsilon^2)$$

$$\pi_{t+1}^P = (2-\delta)\pi_t^P + (\delta - 1)\pi_{t-1}^P + \delta\eta_{1t} \qquad \eta_{1t} \approx N(0, \sigma_\eta^2)\,.$$

Since the model includes unobservable components (π_t^P), we transform the system into the state space form and use state space analysis methods.

---

[12] There is also another possible interpretation of the formula. If the public forecasts inflation ($\pi_{t+1|t}^{forecast}$) in the same way as the central bank (irrespective of what the announced inflation target is) and the central bank behaves such that the inflation forecast equals the inflation target ($\pi_{t+1|t}^{forecast} = \pi_{t+1}^{T}$), then the parameter δ captures the fraction of forward-looking members of the public.

[13] This assumption implies that the resulting form of the Phillips curve is equivalent to the assumption that the data-generating process for inflation has the following form:

$$\pi_t = \mu_t + \sum_{i=1}^{4} \alpha_i (\pi_{t-i} - \mu_t) + \varepsilon_t\,,$$

where the time-varying mean equals the perceived inflation target. This formula is the starting point for parametric measures based on AR(p) representations of the data-generating process (assuming a constant intercept $\mu_t = \mu$). There are several reasons to believe that analysis of inflation persistence (particularly the intrinsic part of inflation persistence) benefit from setting $\beta=0$ due to several practical difficulties related to the use of output gap. First, estimation of the output gap is highly dependent on the choice of estimation method and time series estimated using different methods vary substantially. Second, optimal lag length between the inflation and output gap needs to be determined (set to one in (5) for simplicity). Third, due to limited sample size, the additional parameter would complicate the estimation of system (3)-(5) futher.

$$\begin{bmatrix} \pi_{t+1}^{P} \\ \pi_{t}^{P} \end{bmatrix} = \begin{bmatrix} 2-\delta, \delta-1 \\ 1,0 \end{bmatrix} \begin{bmatrix} \pi_{t}^{P} \\ \pi_{t-1}^{P} \end{bmatrix} + \begin{bmatrix} \delta \\ 0 \end{bmatrix} \eta_{1t}$$

$$\pi_{t} = \left[\left(1 - \sum_{i=1}^{4} \varphi_{i} \right), 0 \right] \begin{bmatrix} \pi_{t}^{P} \\ \pi_{t-1}^{P} \end{bmatrix} + \sum_{i=1}^{4} \varphi_{i} \pi_{t-i} + \varepsilon_{1t}$$

To estimate the unobservable series of perceived inflation π_t^P, we use the exact initial Kalman filter (the case of unknown initial conditions) as described, for example, in Koopman and Durbin (2003). The Kalman filtering assumes known coefficients; therefore, we have to estimate them.

We follow Dossche and Everaert (2005) and use a Bayesian approach combined with the method of importance sampling.

(iii) ARFIMA model

Regarding structural breaks in parameters of the inflation process, the literature points out that stationary processes with structural breaks and fractionally integrated processes can exhibit similar time behavior along with different properties regarding persistence. The application of the fractionally integrated approach in the context of inflation persistence is introduced in Gadea and Mayoral (2006). In addition to formal tests of inflation time series, the authors show how fractionally integrated behavior can emerge in heterogeneous-agent sticky-price models.

While a shock has a permanent effect in I(1) models and disappears at an exponential rate in I(0) models, the fractionally integrated approach allows for richer representation by introducing the so-called fractional differencing parameter *d*, which can be any real number $d \neq 0$. The time series y_t follows a so-called ARFIMA(p,d,q) model if

$$\phi(L)(1-L)^d(y_t-\mu)=\theta(L)\varepsilon_t, \quad (6)$$

where the roots of $\phi(L)$ and $\theta(L)$ lie outside the unit circle and ε_t is white noise.

As advocated by Baum et al. (1999) and Gadea and Mayoral (2006), the ARFIMA model could be an appropriate representation of the stochastic behavior of inflation time series. ARFIMA allows a high degree of persistence without assuming a unit root (i.e., I(1)) character of the process). We follow Gadea and Mayoral (2006) and estimate parameter *d* from (6) as well as the impulse response function of the appropriate ARFIMA model.

Furthermore, we employ the test suggested by Mayoral (2004), which tests the hypothesis of a time series following a fractionally differentiated process of order *d* versus a stationary process with breaks. Unlike Gadea and Mayoral (2006), we allow for a break not only in the level but also in the trend, to reflect the convergence process observed in parts of the inflation series of some countries.

The test statistics have the following form:

$$R(d)=T^{1-2d}\frac{\inf\limits_{\omega\in\Omega}(\sum(y_t-\hat{\alpha}_1-\hat{\delta}_1DC_t-\hat{\beta}_1t-\hat{\delta}_2DT_t)^2)}{\sum(\Delta^d(y_t-\hat{\alpha}_0-\hat{\beta}_0t))^2},$$

where *d* is the order of differentiation, T is the number of periods, Ω = [0.15, 0.85] are trimming thresholds, *y* is the time series considered, DC_t = 1 if $t>\omega T$ and 0 otherwise, and $DT_t = (t-T_B)$ if $t>\omega T$ and 0 otherwise. α_0, α_1, β_0, β_1, δ_1 and δ_2 are coefficients from the appropriate regressions. Δ^d is the operator of differencing of order *d*. Critical values are computed according to Mayoral (2004).

The null hypothesis assumes a fractionally integrated process; the alternative hypothesis assumes a stationary process with breaks.

3.2 Structural measures

Both the theory and practical estimation of the structural Phillips curve have been a subject of heightened debate in recent years, and no consensus concerning the related issues has been achieved so far. We try to stick to the approaches used in the studies mentioned in the literature review to make the international comparison meaningful. However, we stress the possible weaknesses of the approaches that are raised in the literature and that could affect the resulting estimates.

The aim of the structural Phillips curve estimation is to find a formula that captures the short-run inflation dynamics, and consequently enables us to infer the degree of inflation inertia based on the estimation of the formula.

The parameters of the model introduced in Galí and Gertler (1999) are functions of three model primitives: the probability that a firm has to keep its price unchanged (θ) (the degree of price rigidity), the fraction of backward-looking firms that set their price according to the price in the previous period adjusted for inflation (ω), and the discount factor (β).

The closed-economy version of the New Hybrid Phillips Curve (NHPC) takes the following form:

$$\pi_t = \gamma_b \pi_{t-1} + \gamma_f E_t \pi_{t+1} + \lambda mc_t$$

$$\gamma_b = \frac{\omega}{\phi}$$

$$\gamma_f = \frac{\beta\theta}{\phi}$$

$$\lambda = \frac{(1-\omega)(1-\theta)(1-\beta\theta)}{\phi}$$

with $\phi = \theta + \omega[1 - \theta(1-\beta)]$.

Here the variable mc_t represents the percentage deviation of the average real marginal cost from its steady-state value.

The ongoing debate on the theoretical and econometric issues regarding short-run inflation dynamics is even more pronounced for the NMS. Together with the issues mentioned above, one has to deal with incomplete time series, short time spans of data, and a convergence process in the NMS. Therefore, estimating the NHPC for post-transition countries involves some additional issues.

As post-transition countries have been experiencing a transition towards a new steady state, we use an HP filter to filter out non-business cycle frequencies and thus abstract from the convergence path. This approach can result in various biases (for a detailed discussion, see Lendvai, 2005). In addition, Baum et al. (2003) point out that the GMM estimator can exhibit poor properties in the case of small samples, and we therefore follow Lendvai (2005) in employing a 2SLS estimator.

4. Results

In this section we provide the results of the inflation persistence measures introduced in the previous section. To make our results comparable to previous studies, we employ a seasonally adjusted annualized quarter-on-quarter rate of change of the GDP deflator to represent inflation in all the estimates and computations. All the remaining data are thoroughly described in Appendix 1. The time span considered covers the period 1993:2–2006:1, if not stated explicitly otherwise. In the case of Hungary, data are available since 1995:2. The country abbreviations are also explained in Appendix 1.

We provide inflation persistence estimates for individual countries (not only for the whole EU12), since a direct comparison of persistence in individual NMS and the euro area as a group could be misleading. As shown in Cecchetti and Debelle (2006) and discussed in Altissimo, Ehrmann, and Smets (2006) and Batini (2006), aggregation of inflation indices leads to higher persistence estimates. This holds for aggregation from sectoral to country level as well as aggregation from country indices to euro area indices.

4.1 Statistical measures – parametric (autoregressive models)

(i) Constant mean

We start with the estimation of the sum of the autoregressive coefficients.[14] The results of the OLS estimates of ρ_K are reported in Table 2. The estimated persistence reaches 0.68 for Poland and 0.75–0.76 for the Czech Republic, Hungary, and Slovakia. In contrast, the persistence is estimated at below 0.68 for all the other countries. The four NMS thus have higher estimates of inflation persistence than any other country in the sample. A similar pattern (of the six countries with the highest persistence estimates in the sample, four are NMS) is confirmed by estimating the largest autoregressive roots (not reported here).

In Table 3, we report the estimates of ρ_K obtained using Hansen's (1999) grid bootstrap procedure, including 90% confidence intervals. Figure 1 shows the estimates and confidence intervals for the case of $k = 5$ lags. Although the confidence intervals are wide and the estimates embody considerable uncertainty, one pattern is robust across the number of lags considered: the estimates of persistence in the NMS are high and in most cases higher than the persistence in the euro area countries. In all five specifications with different lag lengths, the four NMS rank among the six countries with the highest persistence estimates in the sample.

[14] Note that stationarity tests of the inflation time series are included in the analysis. The estimates of the coefficients for the lag length equal to one (see the last column in Table 3) show that we can reject the null of a unit root for all countries at the 90% significance level.

Table 2: OLS estimates of ρ_K (inflation based on GDP deflator)				
	Preferred model according to AIC		Preferred model according to BIC	
	Number of AR lags	Sum of AR coefficients	Number of AR lags	Sum of AR coefficients
CZE	5	0.75	4	0.76
HUN	5	0.75	4	0.75
POL	4	0.68	4	0.68
SVK	2	0.75	2	0.75
EU12	3	0.66	3	0.66
BEL	2	0.13	2	0.13
ESP	4	0.59	1	0.26
FIN	1	0.33	1	0.33
FRA	1	0.43	1	0.43
GER	4	0.50	3	0.61
GRC	4	0.67	4	0.67
IRL	2	0.11	2	0.11
ITA	2	0.14	2	0.14
NLD	3	0.62	3	0.62
PRT	5	-0.16	5	-0.16

The estimates of persistence in the NMS based on the constant mean assumption could, however, suffer to some extent from upward bias due to the impact of administrative price changes. Gadzinski and Orlandi (2004) as well as Levin and Piger (2004) show that administrative price changes (e.g., changes in VAT) increase the persistence estimates if they are not accounted for. Due to the transition process, the NMS countries experienced numerous administrative price changes during the 1990s. Besides changes in VAT and excise taxes, gradual price deregulations influenced the prices of energy and housing. Since the frequency of these changes and the relatively short sample do not allow us to control for breaks in the way some other studies do, we adopt a different approach.[15]

While we abandon the constant mean assumption in the next section, in Appendix 2 we present the results of the same methodology as before, this time applied to inflation based on non-food, non-energy CPI inflation. The reason is that non-food, non-energy CPI inflation is supposed to be less influenced by price deregulations[16]

[15] Fidrmuc and Tichit (2004) discuss the role of structural breaks in transition data. They attempt to detect structural breaks in a growth regression for a data frequency and time period similar to ours. Kočenda (2005) searches for structural breaks in the exchange rates of European transition countries.
[16] Prices of energy were among the most heavily regulated prices in the NMS over the transition period.

and therefore allows for a better comparison of inflation persistence between the NMS and the rest of the sample. Nevertheless, even in the case of core inflation, the estimates of persistence in the NMS are (with the exception of Slovakia) still higher than in most of the ten other countries.[17] Using Hansen's (1999) grid bootstrap estimation on the core inflation data, we observe that inflation persistence in Slovakia is relatively low, whereas the Czech Republic, Hungary, and Poland rank in the half of the sample with higher persistence, regardless of the number of lags (see Appendix 2 for tables and figures reporting results for core inflation).

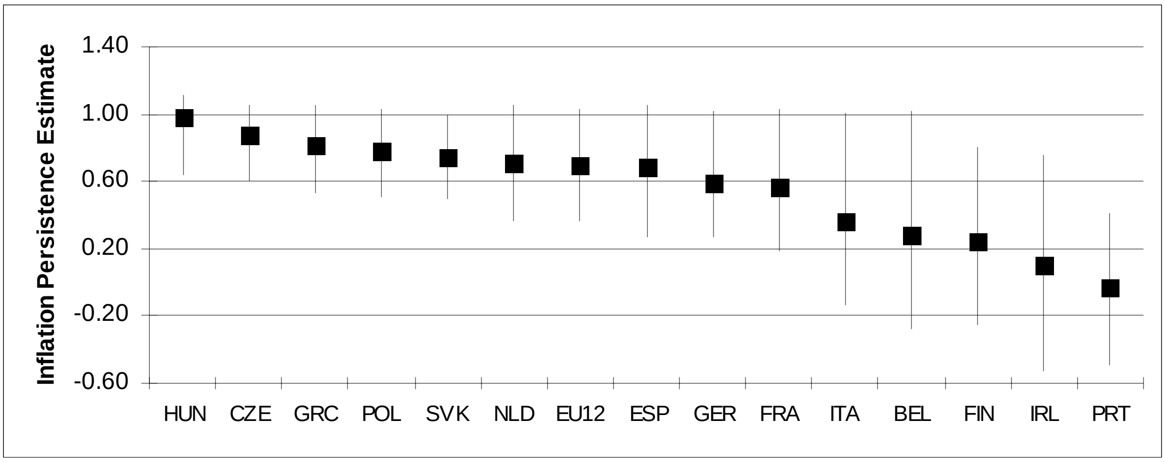
[17] Another reason for including non-food, non-energy CPI inflation is to examine the robustness of our results with respect to the choice of inflation time series.

Table 3: ρ_K and its 90% confidence intervals estimated using Hansen's (1999) grid bootstrap procedure

(inflation based on GDP deflator)

	Lag length = 5			Lag length = 4			Lag length = 3			Lag length = 2			Lag length = 1		
	lower bound	mean	upper bound	lower bound	mean	upper bound	lower bound	mean	upper bound	lower bound	mean	upper bound	lower bound	mean	upper bound
CZE	0.60	**0.88**	1.05	0.62	**0.87**	1.04	0.49	**0.71**	0.96	0.52	**0.76**	1.01	0.43	**0.63**	0.84
HUN	0.64	**0.98**	1.11	0.60	**0.98**	1.10	0.57	**1.00**	1.08	0.44	**0.76**	1.04	0.11	**0.41**	0.68
POL	0.51	**0.78**	1.03	0.55	**0.83**	1.03	0.52	**0.79**	1.04	0.47	**0.69**	0.99	0.27	**0.50**	0.72
SVK	0.49	**0.74**	1.00	0.52	**0.74**	1.00	0.62	**0.85**	1.03	0.64	**0.84**	1.03	0.52	**0.70**	0.89
EU12	0.36	**0.70**	1.03	0.45	**0.78**	1.05	0.48	**0.80**	1.05	0.21	**0.50**	0.84	0.10	**0.33**	0.58
BEL	-0.28	**0.28**	1.02	-0.16	**0.38**	0.94	-0.33	**0.10**	0.54	-0.15	**0.20**	0.56	-0.39	**-0.15**	0.08
ESP	0.27	**0.69**	1.06	0.35	**0.79**	1.07	0.02	**0.37**	0.79	-0.03	**0.24**	0.54	0.05	**0.31**	0.54
FIN	-0.25	**0.24**	0.81	-0.24	**0.12**	0.56	-0.06	**0.29**	0.70	0.12	**0.41**	0.71	0.13	**0.35**	0.62
FRA	0.19	**0.57**	1.03	0.06	**0.36**	0.68	0.27	**0.56**	0.90	0.35	**0.62**	0.96	0.24	**0.47**	0.69
GER	0.27	**0.59**	1.02	0.28	**0.60**	0.98	0.43	**0.72**	1.03	0.16	**0.41**	0.71	0.13	**0.35**	0.58
GRC	0.53	**0.82**	1.06	0.52	**0.54**	1.07	0.07	**0.41**	0.80	0.06	**0.35**	0.63	0.02	**0.24**	0.46
IRL	-0.53	**0.10**	0.76	-0.35	**0.16**	0.73	-0.25	**0.21**	0.74	-0.19	**0.19**	0.57	-0.53	**-0.31**	-0.09
ITA	-0.13	**0.37**	1.01	0.10	**0.56**	1.05	0.01	**0.46**	1.02	-0.15	**0.20**	0.58	-0.32	**-0.06**	0.20
NLD	0.36	**0.71**	1.05	0.49	**0.93**	1.08	0.42	**0.77**	1.05	0.20	**0.52**	0.88	-0.04	**0.20**	0.44
PRT	-0.49	**-0.03**	0.41	-0.20	**0.20**	0.65	-0.23	**0.14**	0.53	-0.10	**0.22**	0.59	-0.18	**0.04**	0.30

Figure 1: Inflation based on GDP deflator, ρ estimate and its 90% confidence intervals
(lag length = 5, Hansen's (1999) grid bootstrap procedure)



(ii) Time-varying mean

In this section, we present the results of the autoregressive model of inflation, allowing for a time-varying mean. The model measures inflation persistence net of the effects of the monetary policy authority.

Tables 4a and 4b report the parameter estimates and 90% confidence intervals obtained by the method of importance sampling.[54] The intrinsic inflation persistence (the sum of the AR coefficients) and expectations-based inflation persistence (δ) are statistically significant.

[54] During the estimation of coefficients for the filtering algorithm we encountered two main numerical problems. First, for Hungary and Ireland the algorithm for finding the minimum of the constrained nonlinear multivariable function does not converge in a reasonable number of iterations. We therefore do not report estimation results for these two countries. Note that minimization is the first step in the method of importance sampling to obtain the importance density. Second, for Greece and Poland we take only a subsample since the full sample Hessian matrix obtained during the minimization is too large to be useful for the importance density. Even for the restricted sample, the Hessian matrix for Poland is quite large and thus the lower and upper bounds of the 90% confidence intervals differ little.

TABLE 4a: Estimation results of the model with a time-varying mean – NMS

	Czech Republic			Poland			Slovakia		
	lower bound	*parameter estimate*	*upper bound*	*lower bound*	*parameter estimate*	*upper bound*	*lower bound*	*parameter estimate*	*upper bound*
φ_1	0.19	0.31	0.54	-0.01	-0.01	-0.01	0.06	0.21	0.32
φ_2	-0.13	0.01	0.09	0.05	0.05	0.05	0.06	0.18	0.29
φ_3	-0.06	0.05	0.18	0.22	0.22	0.22	-0.13	-0.01	0.14
φ_4	-0.21	-0.12	-0.07	-0.14	-0.14	-0.14	-0.21	-0.10	0.00
$\sum_{i=1}^{4}\varphi_i$	-0.12	0.26	0.49	0.12	0.12	0.12	0.10	0.28	0.49
δ	0.16	0.26	0.33	0.07	0.07	0.07	0.15	0.27	0.39
σ_ε^2	2.11	2.37	2.74	2.80	2.80	2.80	1.80	2.04	2.33
σ_η^2	0.05	0.13	0.22	0.12	0.12	0.12	0.02	0.08	0.17

TABLE 4b: Estimation results of the model with a time-varying mean – EU12

	Belgium			Finland			France		
	lower bound	*parameter estimate*	*upper bound*	*lower bound*	*parameter estimate*	*upper bound*	*lower bound*	*parameter estimate*	*upper bound*
φ_1	-0.06	0.08	0.23	0.16	0.19	0.25	0.12	0.26	0.40
φ_2	0.05	0.20	0.35	-0.01	0.06	0.13	0.01	0.16	0.30
φ_3	-0.15	0.00	0.14	-0.12	-0.04	0.05	-0.12	0.02	0.16
φ_4	0.04	0.18	0.32	-0.25	-0.15	-0.07	-0.22	-0.07	0.08
$\sum_{i=1}^{4}\varphi_i$	0.11	0.45	0.86	-0.09	0.07	0.21	0.07	0.37	0.67
δ	0.06	0.21	0.37	0.15	0.23	0.39	0.09	0.22	0.37
σ_ε^2	0.87	1.15	1.46	2.10	2.28	2.36	0.40	0.58	0.82
σ_η^2	0.00	0.03	0.09	0.00	0.02	0.09	0.00	0.04	0.10

	Germany			Greece			Italy		
	lower bound	*parameter estimate*	*upper bound*	*lower bound*	*parameter estimate*	*upper bound*	*lower bound*	*parameter estimate*	*upper bound*
φ_1	0.06	0.20	0.35	-0.18	-0.06	0.00	-0.11	0.03	0.14
φ_2	-0.07	0.07	0.22	-0.19	-0.09	0.00	-0.01	0.11	0.24
φ_3	0.08	0.22	0.36	-0.21	-0.12	-0.03	0.00	0.13	0.28
φ_4	-0.14	0.00	0.14	0.30	0.40	0.57	-0.09	0.06	0.16
$\sum_{i=1}^{4}\varphi_i$	0.19	0.50	0.85	-0.09	0.13	0.43	0.13	0.33	0.57
δ	0.09	0.22	0.37	0.12	0.20	0.29	0.08	0.20	0.37
σ_ε^2	0.70	0.94	1.25	1.87	2.19	2.39	1.80	2.05	2.30
σ_η^2	0.00	0.03	0.09	0.00	0.04	0.09	0.00	0.04	0.11

	Netherlands			Portugal			Spain		
	lower bound	*parameter estimate*	*upper bound*	*lower bound*	*parameter estimate*	*upper bound*	*lower bound*	*parameter estimate*	*upper bound*
φ_1	0.01	0.14	0.26	-0.12	-0.01	0.13	0.08	0.22	0.36
φ_2	0.07	0.20	0.34	-0.09	0.04	0.16	-0.10	0.04	0.18
φ_3	0.06	0.19	0.33	-0.14	-0.03	0.10	-0.08	0.07	0.21
φ_4	-0.02	0.11	0.24	0.09	0.19	0.31	0.04	0.18	0.32
$\sum_{i=1}^{4}\varphi_i$	0.36	0.64	0.97	-0.13	0.19	0.51	0.17	0.50	0.90
δ	0.10	0.23	0.39	0.10	0.26	0.40	0.11	0.23	0.37
σ_ε^2	1.44	1.71	1.99	1.62	1.90	2.17	0.88	1.16	1.48
σ_η^2	0.00	0.05	0.12	0.00	0.03	0.10	0.00	0.05	0.12

Note: Data: seasonally adjusted q-o-q change of the GDP deflator.
Time span: 1993:1–2006:1, Greece since 1994:4, and Poland since 1995:3.
The results reported were obtained by importance sampling.
90% confidence interval bounds are reported.

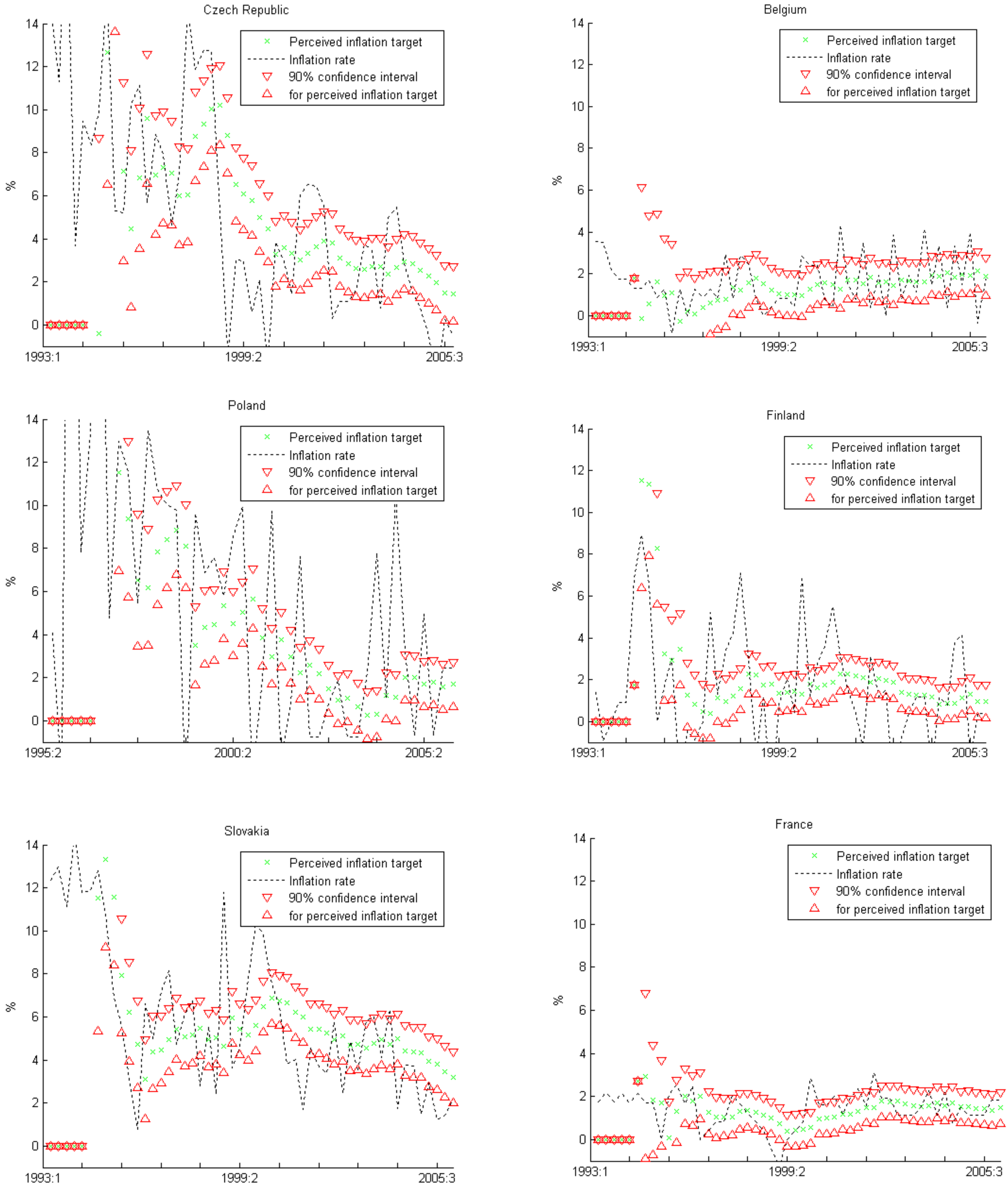
Tables 4a and 4b provide a parameter estimate comparison of the extent of inflation persistence in the selected NMS and euro area countries. Because of possible aggregation bias, we compare inflation persistence at the level of individual countries. The table suggests that for the Czech Republic, Poland, and Slovakia inflation persistence adjusted for the effects of monetary policy is close to the group of euro area countries with lower inflation persistence (Finland, Portugal). For example, the intrinsic and extrinsic inflation persistence in Slovakia is 0.28, while in Belgium the persistence reaches 0.45. On the other hand, the 90% confidence intervals often reject statistical differences in inflation persistence between countries.

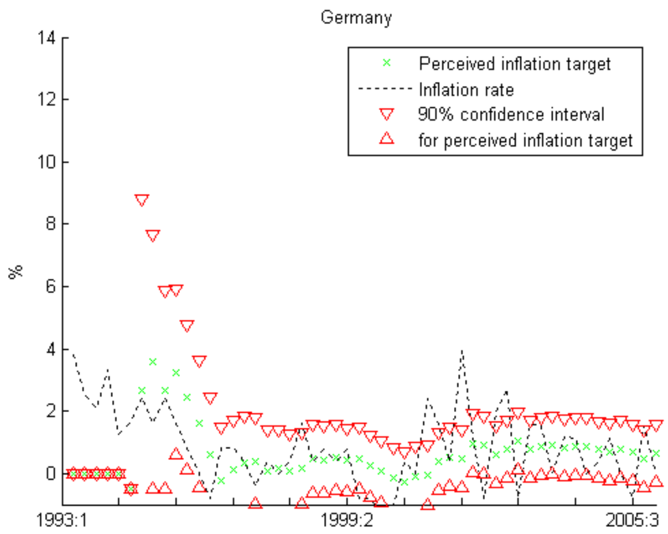
The time-varying mean model enables a discussion of the credibility of monetary authorities and the extent of expectations-based persistence. The values of parameter δ are lower for the selected NMS than for the selected euro area countries, suggesting that the public in the NMS sets its expectations about inflation rates less in accordance with the modeled targets announced by central banks than in the euro area countries (or alternatively, that the fraction of forward-looking members of the public is lower in the selected NMS). The conclusion often holds even in terms of 90% confidence intervals.

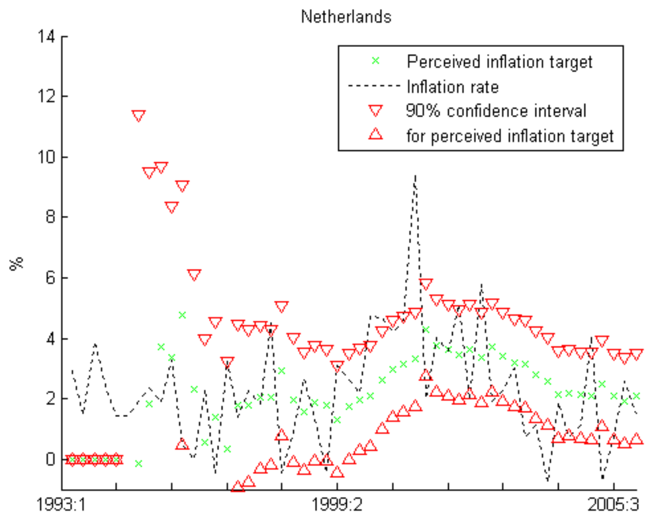
Finally, the Czech Republic, Poland, and Slovakia experience higher variance of shocks to the modeled inflation target and also of shocks in the inflation equation than the euro area countries. This is a consequence of the transition in the 1990s, which included cost-push shocks, significant changes in monetary strategies, etc.

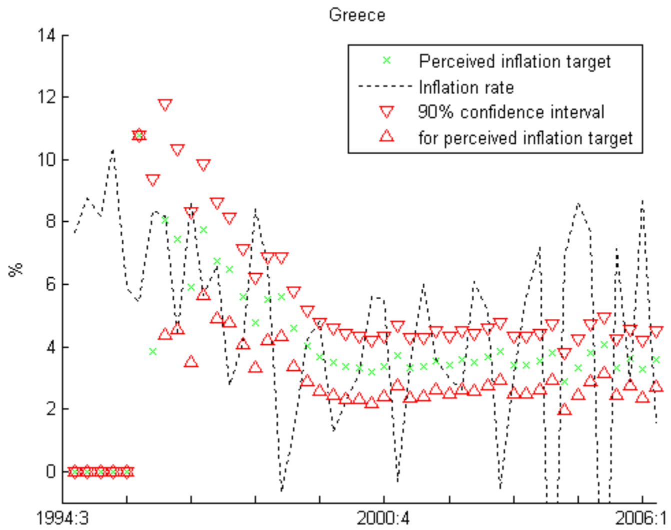
With the estimated parameters, it is possible to use the exact initial Kalman filter method to estimate the unobservable components of the system. The results of the Kalman filtering are depicted in Figure 2. Note that the inflation target pursued by the central bank is modeled as a random walk and the perceived inflation target that serves as a time-varying mean follows an AR(2) process.

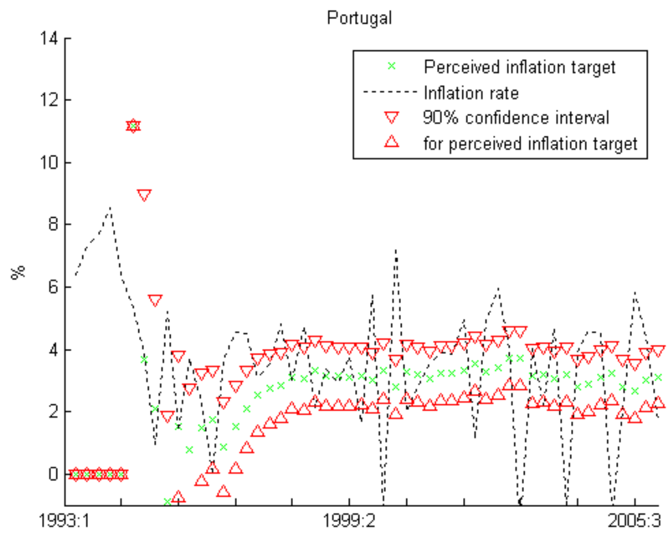
Figure 2: Perceived targets in the time-varying mean models.

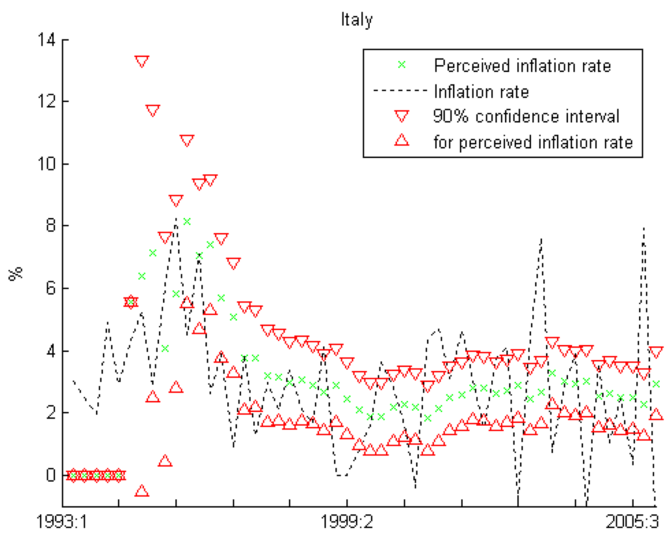


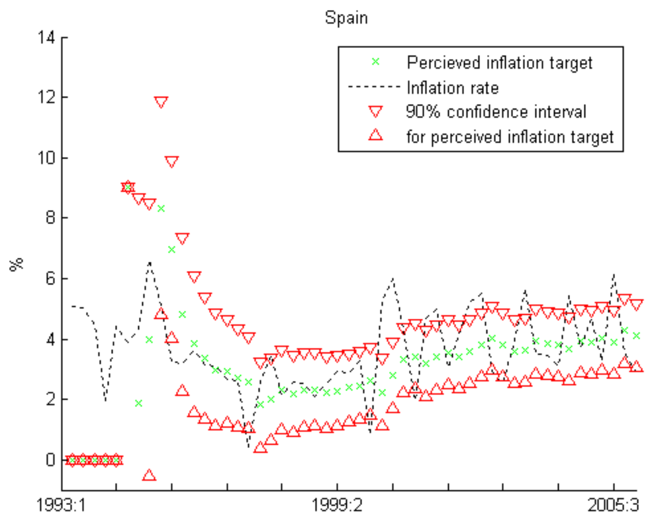

Germany
Perceived inflation target
Inflation rate
90% confidence interval
for perceived inflation target
%
1993:1
1999:2
2005:3


Netherlands
Perceived inflation target
Inflation rate
90% confidence interval
for perceived inflation target
%
1993:1
1999:2
2005:3


Greece
Perceived inflation target
Inflation rate
90% confidence interval
for perceived inflation target
%
1994:3
2000:4
2006:1


Portugal
Perceived inflation target
Inflation rate
90% confidence interval
for perceived inflation target
%
1993:1
1999:2
2005:3


Italy
Perceived inflation rate
Inflation rate
90% confidence interval
for perceived inflation rate
%
1993:1
1999:2
2005:3


Spain
Percieved inflation target
Inflation rate
90% confidence interval
for perceived inflation target
%
1993:1
1999:2
2005:3

First note that the 90% confidence intervals for the perceived inflation target time series are zero for the few first quarters, and then larger in comparison to the rest of the time span considered. This is a consequence of the exact initial Kalman filter method, which assumes infinite variances for the initial values of the unobserved components (π_0^P) of the system. Thus we do not report the first few confidence intervals, so as to keep the figures in a reasonable range.

The figures suggest why classical measures of inflation persistence could be inappropriate, especially for the NMS. While the time-varying mean (the perceived inflation target) exhibits breaks for the NMS, no such clear breaks can be observed for the euro area countries.

The figures also capture the effect that the adoption of inflation targeting had on the inflation perceived by the public. For example, in the Czech Republic inflation targeting was adopted in 1997/1998. A year later a switch in the formation of the public perception of inflation can be observed. Since then, the time-varying mean of inflation has been close to the target of 3%.

(iii) The ARFIMA model

First we estimate the fractional differencing parameter *d.* We opt for Geweke and Porter-Hudak's technique[55] and report the results in Table 5a. Based on the estimated value of parameter *d*, we estimate the impulse response function of ARFIMA(0,*d*,0).[56] To compare the persistence of shocks in the time series, we follow Gadea and Mayoral (2006) and report the values of the impulse response function for selected time horizons (*h=4* and *h=12*) after the realization of a shock.

The results show that Hungary, Poland, and Slovakia score high in the persistence suggested by ARFIMA, together with Greece and Spain. The Czech Republic ranks midway in the whole sample of 14 countries.

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[55] Implemented in STATA by Baum and Wiggins (1999).

[56] The impulse response function measures the effects of the realization of a shock in y_t on subsequent values of the time series. See Andrews and Chen (1994) for details. We used the STATA implementation for ARFIMA written by Baum (2000).

To assess the relevance of the ARFIMA model in inflation modeling, we test the hypothesis that inflation series follow a fractionally integrated process, against the hypothesis that the series follow a stationary process with breaks. The results of the test outlined in subsection 3.1 are reported in Table 5b. In most cases, the fractionally integrated process hypothesis can be rejected at the 1% level. The only inflation process for which we cannot reject the null of a fractionally integrated process at any reasonable significance level is the inflation series for Slovakia.

Table 5a: Estimation of fractional differencing parameter *d* and value of impulse response function for selected time horizons

Inflation based on GDP deflator

Country	*d*	SE(*d*)	IPF(4)	IPF(12)
Czech Republic	0.59	0.25	0.38	0.24
Hungary	0.74	0.21	0.56	0.42
Poland	0.93	0.15	0.87	0.81
Slovakia	0.90	0.42	0.81	0.73
Belgium	0.63	0.33	0.42	0.28
Spain	0.84	0.32	0.72	0.60
EU12	0.75	0.21	0.58	0.44
Finland	0.23	0.63	0.08	0.04
France	0.19	0.28	0.07	0.03
Germany	0.54	0.29	0.32	0.20
Greece	1.06	0.14	1.13	1.20
Ireland	0.22	0.20	0.08	0.03
Italy	0.40	0.33	0.20	0.10
Netherlands	0.75	0.24	0.57	0.43
Portugal	0.52	0.32	0.30	0.18

Table 5b: Test of fractional integration process of order *d* versus stationary process with breaks

Country	*d* 0.5	0.6	0.7	0.8	0.9
Czech Republic	0.817	**0.353** **	0.151 *	0.064	0.027
Hungary	0.604 ***	0.258 ***	**0.110** ***	0.046 **	0.020 *
Poland	0.507 ***	0.212 ***	0.088 ***	0.036 ***	**0.015** ***
Slovakia	0.784 *	0.342 **	0.147 **	0.062	**0.026**
Belgium	0.615 ***	**0.252** ***	0.103 ***	0.042 ***	0.017 **
Spain	0.658 ***	0.281 ***	0.119 ***	**0.050** *	0.021 *
EU12	0.659 ***	0.280 ***	0.118 ***	**0.049** **	0.020 *
Finland	**0.774** *	0.337 **	0.145 **	0.062	0.026
France	**0.700** ***	0.308 ***	0.133 **	0.057	0.024
Germany	**0.675** ***	0.287 ***	0.121 ***	0.050 *	0.021 *
Greece	0.614 ***	0.255 ***	0.105 ***	0.043 **	0.018 **
Ireland	**0.546** ***	0.223 ***	0.090 ***	0.037 ***	0.015 ***
Italy	**0.611** ***	0.254 ***	0.105 ***	0.043 **	0.018 **
Netherlands	0.623 ***	0.261 ***	**0.109** ***	0.045 **	0.018 **
Portugal	**0.592** ***	0.246 ***	0.102 ***	0.042 ***	0.017 **
1% critical values	0.715	0.335	0.132	0.043	0.016
5% critical values	0.768	0.364	0.147	0.050	0.020
10% critical values	0.797	0.381	0.156	0.054	0.022

Notes: Computation of the test statistics and critical values are based on Mayoral (2004). ***, **, and * denote the significance at 1%, 5% and 10% levels, respectively. For each country, the cell in bold determines the column closest to the value of d estimated using the Geweke and Porter-Hudak technique and reported in Table 5.

4.2 Structural measures

The estimation of the New Hybrid Phillips Curve (NHPC) is significantly influenced by the data availability, especially for Slovakia. Some time series are only available for part of the time span considered. Moreover, some time series are available only annually. Therefore, we compromise between data availability and the ability to carry out the analysis, and use yearly instead of quarterly data for some instruments. The data used are described in Appendix 1.

We estimate the closed version of the model, since the instrument set employed performs poorly for the open economy version of the NHPC. As is usual in the related literature, we assume rational expectations. The future actual inflation rate, therefore, stands for the expected inflation rate in the estimation of the NHPC.

Zhang et al. (2006) point out the influence of the instrument set on the estimation results, especially when autocorrelation of residuals is present. We employ the sets of instruments introduced in Galí and Gertler (1999), Galí, Gertler, and López-Salido (2001), Zhang et al. (2006), and Lendvai (2005). We also add some instruments that we think are valid for the estimation in the case of the NMS. Table 6 below reports the estimation results for the Czech Republic, Poland, and Slovakia for various sets of instruments. The estimates for Hungary are available in Lendvai (2005). Staiger and Stock (1997) suggest a rule of thumb for instrument relevance: the F-statistics of the overall relevance of excluded instruments should exceed 10. F-statistics below 10 imply a bias in the estimated coefficients. We therefore do not report estimation results for sets of instruments that are not relevant according to this criterion.

TABLE 6: New Hybrid Phillips Curve: Estimation for Various Sets of Instruments – Czech Republic, Poland and Slovakia

Excluded instruments (lags) see Appendix 1	Czech Republic						Poland						Slovakia					
	GG	GGL	ZO	L	IS1	IS2	GG	GGL	ZO	L	IS1	IS2	GG	GGL	ZO	L	IS1	IS2
infl_d	2,3,4	2,3,4,5	x	2	2,3	x	2,3,4	2,3,4,5	x	2	2,3	x	2,3,4	2,3,4,5	x	2	2,3	x
lrulc_d	2,3,4	1,2	x	1,2	2,3	x	2,3,4	1,2	x	1,2	2,3	x	2,3,4	1,2	x	1,2	2,3	x
irspread	1,2,3,4	x	x	x	1,2,3,4	x	1,2,3,4	x	x	x	1,2,3,4	x	1,2,3,4	x	x	x	1,2,3,4	x
ogap	1,2,3,4	x	x	x	1,2	x	x	x	x	x	x	x						
deficit	x	x	x	1,2	1,2	x	x	x	x	1,2	1,2	x	x	x	x	1,2	1,2	x
diff_rer_d	x	x	x	1,2	0,1,2	x	x	x	x	1,2	0,1,2	x	x	x	x	1,2	0,1,2	x
rer_d	x	x	x	0	x	x	x	x	x	0	x	x	x	x	x	0	x	x
u_rate	x	x	1,2,3,4	x	x	1,2	x	x	1,2,3,4	x	x	1,2	x	x	1,2,3,4	x	x	1,2
diff_treasury	x	x	1,2,3,4	x	x	1,2,3,4	x	x	1,2,3,4	x	x	1,2,3,4						
output_d	x	1,2	x	x	x	1,2,3,4	x	1,2	x	x	x	1,2,3,4	x	1,2	x	x	x	1,2,3,4
rg_exp_d	x	x	1,2,3,4	x	x	x	x	x	1,2,3,4	x	x	x						
winfl_d	1,2,3,4	1,2	x	1,2	1,2,3,4	x	x	x	x	x	x	x						
cap_ut	x	x	1,2,3,4	x	x	1,2,3,4	x	x	x	x	x	x						
diff_1day	x	x	1,2,3,4	x	x	1,2,3,4	x	x	1,2,3,4	x	x	1,2,3,4	x	x	1,2,3,4	x	x	1,2,3,4
Results																		
$\hat{\gamma}_f$	0.47*		0.45*		0.42*	0.42*		-0.66**	-0.35			0.02					0.18	0.34
	(0.14)		(0.12)		(0.14)	(0.12)		(0.28)	(0.23)			(0.27)					(0.36)	(0.24)
$\hat{\gamma}_b$	0.35*		0.38*		0.35*	0.38*		-0.31**	-0.26***			-0.19					0.14	-0.02
	(0.08)		(0.09)		(0.07)	(0.09)		(0.15)	(0.13)			(0.15)					(0.18)	(0.15)
$\hat{\lambda}$	-0.09		-0.06		-0.06	-0.04		-0.05	-0.05			-0.05					0.15	0.13
	(0.18)		(0.16)		(0.16)	(0.15)		(0.07)	(0.06)			(0.05)					(0.12)	(0.11)
Instrument relevance																		
F statistics	10.81	1.09	19.51	1.06	72	35.26	3.12	10.46	13.84	2.59	1.84	30.9	8.75	3.64	7.64	1.8	15.41	11.76
Partial R2	0.56	0.19	0.59	0.28	0.57	0.58	0.41	0.34	0.41	0.23	0.08	0.53	0.45	0.14	0.33	0.12	0.49	0.46

* 1% significance level   ** 5%   ***10%

3-lag HAC-robust standard errors are reported in parentheses.

Estimation results for relevant (F statistics above 10) sets of instruments are reported.

We employ instrument sets that replicate Galí and Gertler (1999) **GG**, Galí, Gertler and López-Salido (2001) **GGL**, Zhang et al. (2006) **ZO**, and Lendvai (2005) **L**. We also add some instruments that we consider as valid for the estimation: **IS1** and **IS2**.

For a definition of these instruments, see Appendix 1. The suffix _d denotes HP filtered time series.

In Table 6, the numbers in the upper panels report the lags of the variables that are included in the various sets of instruments. The panels in the middle of the table provide estimates of the reduced form coefficients. Finally, the lower panels report F-statistics and partial R^2.

For sets of instruments resulting in F-statistics above 10, we carry out a Hansen J test for overidentifying restrictions. In all cases we cannot reject the null of satisfied overidentifying restrictions at all relevant significance levels. Furthermore, we test for homoskedasticity employing the Pagan-Hall test and for residual autocorrelation using the Breusch-Godfrey test. We detect serially correlated residuals in all cases and we reject homoskedasticity for Poland.[57] Based on the results of the diagnostics test mentioned, we correct for serial correlation and heteroskedasticity using three-lag HAC-robust standard errors.

Overall, the estimation results suggest that the structural NHPC is not an appropriate short-run inflation dynamics model for Poland and Slovakia. The estimated coefficients for these countries are not significant and often have a sign that does not correspond to the underlying theory. On the other hand, for the Czech Republic the estimated reduced form coefficients $\hat{\gamma}_f, \hat{\gamma}_b$ of the model are significant with the expected sign and within the range predicted by the micro theory. However, the slope parameter on the real marginal cost term $\hat{\lambda}$ is not statistically significant.

We focus on comparison of the reduced form coefficients $\hat{\gamma}_b, \hat{\gamma}_f$, since we are mainly interested in the extent of inflation inertia.[58] A detailed analysis of the structural Phillips curve estimation lies beyond the scope of this current study. The comparison suggests that the predominance of expected future inflation over past inflation seen in the euro area (and the US) is not detected for the Czech Republic and Hungary.[59] If we follow the definition of (intrinsic) inflation persistence from previous sections, we can conclude that the Czech Republic and Hungary exhibit comparable or higher inflation persistence than the euro area countries. Moreover, the lower predominance of the forward-looking term is in accordance

[57] For a discussion of the possible sources of residual autocorrelation, see Galí, Gertler, and López-Salido (2001).
[58] Note that the reduced form coefficients are a sole function of deep parameters.
[59] See the results for the US, the euro area, and Hungary in Galí and Gertler (1999), Galí, Gertler, and López-Salido (2001), Zhang et al. (2005), and Lendvai (2005). We summarize the results of interest in the next section.

with the results of statistical measures based on the autoregressive model with a time-varying mean from the preceding subsection.

5. Summary of results

Our paper provides results in two areas. First, on the methodological level, we summarize the measures available for estimating inflation persistence, such as various types of autoregressive models, including fractionally integrated, and the New Hybrid Phillips Curve (NHPC). We discuss which measures should be used to assess inflation persistence in the NMS, which have certain specific economic characteristics imposed by the current convergence process as well as echoes of the transformation process. Second, we provide empirical estimates of inflation persistence in the NMS and compare them to those obtained for the current euro area Member States.

Starting with the first area, we consider three statistical measures (the autoregressive model with a constant mean and with a time-varying mean, and the autoregressive fractionally integrated moving average model) and a structural measure (the estimated New Hybrid Phillips Curve). We argue that time-varying mean models should be a preferred option for inflation persistence measurement in the NMS as far as the statistical measures are concerned. According to our results, the constant mean assumption is too restrictive for estimating inflation persistence in the NMS. Constant means cannot fully capture the fact that the medium-run equilibrium gradually moves toward the long-run equilibrium in our data samples covering both the transformation and convergence processes. The constant mean models therefore overestimate the actual persistence by assuming that the medium-run and long-run equilibria are identical. Moreover, changes in expectations and monetary policy regimes are likely to contribute to changes in perceived inflation targets, which are closely related to the means estimated from the data. Given the frequency of changes in targets and even in monetary policy regimes in the NMS, the constant mean assumption is not appropriate. We also find that the time-varying mean models are superior to the ARFIMA models for most of the countries considered.

The empirical findings correspond to the methodological discussion. Estimating the inflation persistence under the constant mean assumption, we find that in our sample of 14 countries the NMS (the Czech Republic, Hungary, Poland, and Slovakia) score very high (Table 7). Their values of inflation persistence are among the top five. Only Greece has a comparable persistence level. In this exercise, the Czech Republic has the highest or second highest inflation persistence values. However, when we use the superior statistical measure and assume a time-varying mean, we see a completely different picture. The five countries with the highest inflation persistence are the Netherlands, Spain, Germany, Belgium, and France. The Czech Republic and Slovakia, together with Italy, Portugal, and Greece, form the middle group with mild inflation persistence. Poland and Finland appear to have the lowest inflation persistence in our sample. We therefore conclude that the NMS as a group have comparable inflation persistence to that in the current euro area Member States. This conclusion is also supported by the fact that the 90% confidence intervals often reject statistical differences in inflation persistence between the countries in our sample.

Table 7: Summary of results – statistical measures

	ρ_K (OLS)		ρ_K (Hansen) lag =5		$\Sigma \varphi_i$ (Time-varying mean)	
Czech Republic	0.75 - 0.8	(1)	0.88	(2)	0.26	(8)
Hungary	0.75	(2-3)	0.98	(1)	X	
Poland	0.68	(4)	0.78	(4)	0.12	(11)
Slovakia	0.75	(2-3)	0.74	(5)	0.28	(7)
EU12	0.66	(x)	0.70	(x)	X	
Belgium	0.13	(12)	0.28	(11)	0.45	(4)
Spain	0.26 - 0.6	(10)	0.69	(7)	0.50	(2-3)
Finland	0.33	(9)	0.24	(12)	0.07	(12)
France	0.43	(8)	0.57	(9)	0.37	(5)
Germany	0.50 - 0.6	(7)	0.59	(8)	0.50	(2-3)
Greece	0.67	(5)	0.82	(3)	0.13	(10)
Ireland	0.11	(13)	0.10	(13)	X	
Italy	0.14	(11)	0.37	(10)	0.33	(6)
Netherlands	0.62	(6)	0.71	(6)	0.64	(1)
Portugal	-0.16	(14)	-0.03	(14)	0.19	(9)

Note: For each approach, we report parameter estimates. Intervals indicate estimates by various methods as presented in the paper. In brackets, the countries are ordered according to the scope of estimated inflation persistence.

To underpin the discussion with measures based on structural parameters, we estimate the New Hybrid Phillips Curve. To the previously published results for Hungary, we add our estimates of the NHPC for the Czech Republic (Table 8). For these two NMS, backward-looking price setting behavior is relatively more important than for the current euro area Member States, where forward-looking behavior dominates. This result might indicate that although inflation persistence in the NMS is comparable to that in the current euro area Member States, it does not have the same roots.

In comparison to Hungary, the role of the forward-looking term is even less important for the Czech Republic, while the backward-looking terms are similarly important. The estimates for the Czech Republic are obtained by various methods. We conclude that our results for the Czech Republic are relatively robust, since they do not vary as much as in the case of various studies of the euro area NHPC.

Table 8: Estimates of the New Hybrid Phillips Curve in various studies

	Czech Republic	Hungary	euro area					
Coefficient	Summary	L (2005)	Summary	GG (1999) a	GG (1999) b	GGL (2001) a	GGL (2001) b	ZO (2005)
$\hat{\gamma}_b$	0.42-0.47	0.467	0.04-0.59	0.252	0.378	0.043	0.272	0.587
		(0.084)		(0.023)	(0.020)	(0.115)	(0.072)	(0.085)
$\hat{\gamma}_f$	0.35-0.38	0.553	0.43-0.77	0.682	0.591	0.773	0.689	0.429
		(0.084)		(0.020)	(0.016)	(0.064)	(0.047)	(0.089)

Note: See Galí and Gertler (1999) – Table 2, Galí, Gertler, and López-Salido (2001) – Table 2, Zhang et al. (2005) – Table 2, and Lendvai (2005) – Table 3a. The two versions of Galí and Gertler (1999) and Galí, Gertler, and López-Salido (2001) correspond to the two versions of orthogonality conditions. For the euro area the GDP deflator is used; Lendvai (2005) uses core inflation. Standard errors are reported in parentheses.

6. Conclusions

Our first conclusion is that one should be very careful when selecting and interpreting empirical measures of inflation persistence. An inappropriate measure, based on the assumption of a constant mean, can send a very misleading signal suggesting that high inflation persistence poses an enormous problem for the NMS. Moreover, comparing levels of persistence between countries should be done carefully, since the confidence intervals are quite wide, and consequently the most frequent outcome of such a comparison is that countries do not have significantly different inflation persistence levels.

Nevertheless, we find the following empirical results relevant to the policy discussion about the euro and the NMS. Out of the three sources of inflation persistence (intrinsic, extrinsic, and expectations-based), the first two seem to be of comparable importance in the NMS and the euro area. This might be partially due to the fact that the way wages and prices are set, as well as the persistence in the inflation-driving real variables, is similar across European countries. In addition, our estimates of the time-varying mean models clearly show that changes in expectations and monetary policy regimes are crucial in analyzing inflation persistence in the NMS.

Finally, based on the estimation of the New Hybrid Phillips Curve we find that the NMS in our sample are more backward-looking than the current members of the euro area. The empirical results, which identify a more backward-looking nature of inflation and larger shifts in perceived inflation targets in the NMS than in the euro area, indicate that anchoring inflation expectations should become a very important part of the euro adoption strategy for the NMS. Despite the fact that the perceived inflation targets in the NMS are now similar to those of the current euro area members, the NMS should pay attention to expectations-based persistence.

7. References

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Appendix 1: Data description

Inflation based on the GDP deflator: seasonally adjusted annualized q-o-q rate of change of the GDP deflator as published in the OECD OEO Database. Time span: 1993:2–2006:1. The exception is Hungary, for which we used the time span 1995:1–2006:1. Transformation: $inf_{GDP} = 400ln(GDPdefl/GDPdefl_{-1})$.

Inflation based on non-food, non-energy CPI: annualized q-o-q rate of change of the Consumer Price Index as published in the OECD MEI Database. Timespan: 1996:2–2006:2. Transformation: $inf_{coreCPI} = 400ln(coreCPI/coreCPI_{-1})$.

Country name abbreviations: BEL (Belgium), CZE (Czech Republic), FIN (Finland), FRA (France), GER (Germany), GRC (Greece), HUN (Hungary), IRL (Ireland), ITA (Italy), NLD (Netherlands), POL (Poland), PRT (Portugal), SVK (Slovakia), ESP (Spain)

The structural Phillips curve is estimated based on quarterly data covering the period 1993:2–2006:1 for the Czech Republic and Poland, and 1995:2–2006:1 for Slovakia.[60] We take over inflation based on the GDP deflator (*infl*) and the real effective exchange rate (*reer*) from the preceding analysis. Real marginal costs are represented by the log of real unit labor costs deflated by the GDP deflator (*lrulc*). In addition, we employ the following series:

ogap: output gap as a percentage of total GDP
irspread: difference between short-term (1 day) and long-term (3 months) interest rate
deficit: government surplus or deficit in terms of GDP
rer: real exchange rate
diff_rer: q-o-q change of real exchange rate
u_rate: unemployment rate
diff_treasury: first difference of long-term interest rate (10 years)
output: GDP
rg_exp: real government expenditure (deflated by GDP deflator)
winfl: wage inflation (annualized q-o-q change)

[60] The data were downloaded from the ECB Statistical Data Warehouse. The data sources are: OECD Economic Outlook, OECD Main Economic Indicators, ECB Euro Area Accounts and Economic Statistics – Government Statistics and ESA, and the Czech Statistical Office.

cap_ut: capacity utilization

diff_1day: first difference of short-term interest rate.

The output gap is available for the Czech Republic and for the period 1995:1–2006:1 only; we impose zeros for the period 1993:1–1994:4. The government deficit is available annually since 1995:1 (we impose zeros for the period 1993:1–1994:4). GDP is available quarterly since 1996 for the Czech Republic and since 1995 for Poland. Only annual values for the long-term interest rate (10 years) are available for Slovakia, and therefore we do not include *diff_treasury* in the analysis for that country. Quarterly values of the long-term interest rate (10 years) are available since 1999:2 for Poland. Government expenditures are available since 1996 for Poland; we impose values as of 1996 in the period before. For Slovakia, government expenditures are not available. For the Czech Republic, wage inflation is available quarterly since 1998; annual values are available in the preceding period. Time series of wage inflation and capacity utilization are not available for Slovakia and Poland.

Appendix 2: Sum of autoregressive coefficients – core inflation

Table: OLS estimates of ρ_K
(inflation based on non-food, non-energy CPI)

	Preferred model according to AIC		Preferred model according to BIC	
	Lag length	Sum of AR coefficients	Lag length	Sum of AR coefficients
CZE	4	0.75	2	0.65
HUN	4	0.85	4	0.85
POL	4	0.84	4	0.84
SVK	1	0.21	1	0.21
BEL	5	-0.14	5	-0.14
ESP	3	-1.56	1	-0.95
FIN	5	0.65	5	0.65
FRA	4	0.75	4	0.75
GER	4	0.20	4	0.20
GRC	4	0.51	4	0.51
IRL	5	0.49	4	0.57
ITA	4	0.33	2	-0.05
NLD	5	0.67	4	0.85
PRT	4	0.72	4	0.72

Figure 2: Inflation based on non-food, non-energy CPI, ρ estimate and its 90% confidence intervals
(lag length = 5, Hansen's (1999) grid bootstrap procedure)

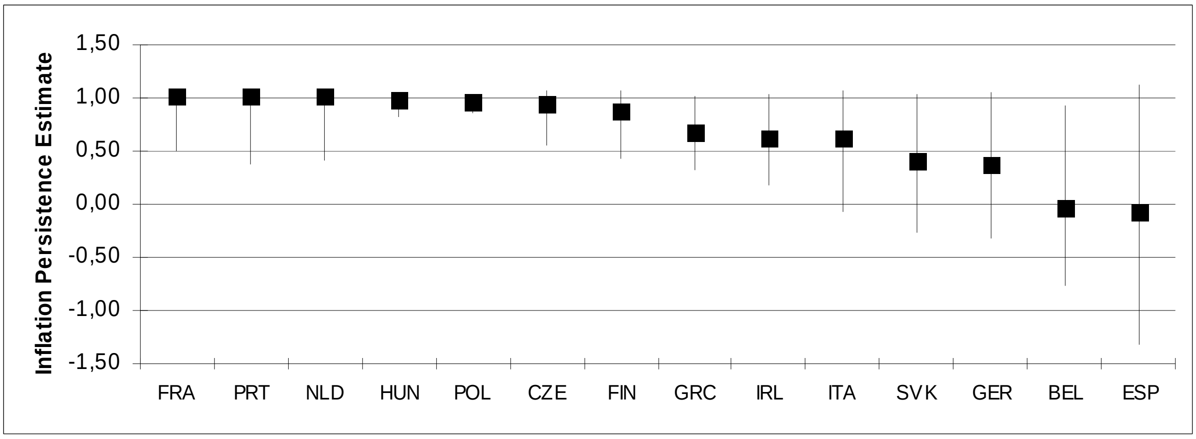
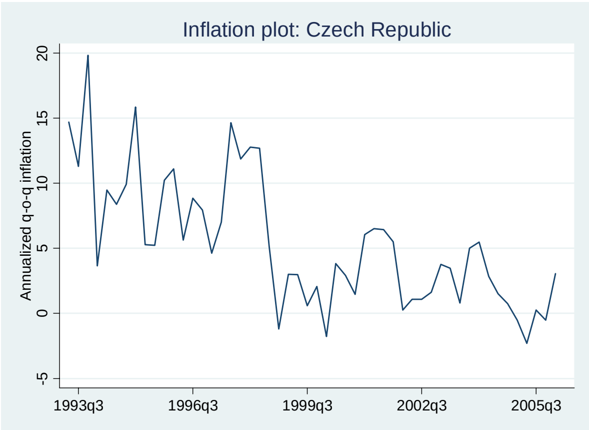
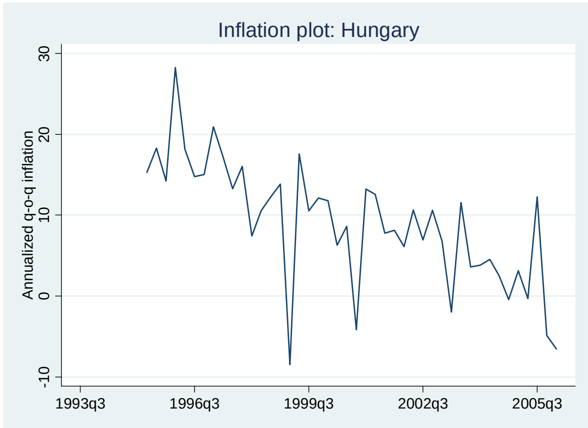


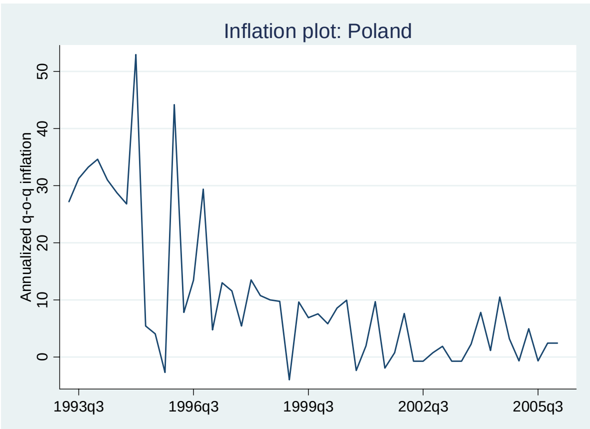
Table: ρ_K and its 90% confidence intervals estimated using Hansen's (1999) grid bootstrap procedure
(inflation based on non-food, non-energy CPI)

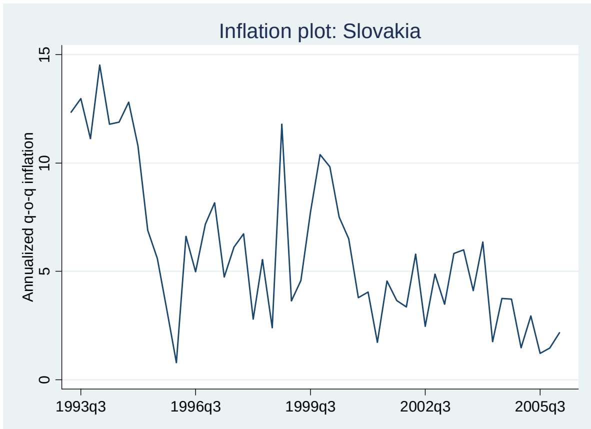
	Lag length = 5			Lag length = 4			Lag length = 3			Lag length = 2			Lag length = 1		
	lower bound	mean	upper bound	lower bound	mean	upper bound	lower bound	mean	upper bound	lower bound	mean	upper bound	lower bound	mean	upper bound
CZE	0.55	**0.95**	1.07	0.60	**1.00**	1.09	0.44	**0.80**	1.04	0.50	**0.81**	1.04	-0.33	**-0.06**	0.17
HUN	0.83	**0.98**	1.04	0.81	**0.95**	1.02	0.73	**0.99**	1.06	0.26	**0.53**	0.83	0.33	**0.55**	0.79
POL	0.85	**0.97**	1.03	0.81	**0.92**	0.99	0.79	**0.99**	1.05	0.76	**0.96**	1.04	0.71	**0.86**	1.02
SVK	-0.26	**0.41**	1.04	0.02	**0.54**	1.05	-0.19	**0.28**	0.79	-0.03	**0.33**	0.75	-0.02	**0.24**	0.53
BEL	-0.77	**-0.03**	0.93	-0.49	**0.28**	1.06	-0.82	**-0.20**	0.46	-0.40	**0.08**	0.59	-0.63	**-0.38**	-0.14
ESP	-1.32	**-0.08**	1.13	-2.11	**-1.03**	0.10	-2.23	**-1.51**	-0.78	-1.31	**-0.76**	-0.18	-1.06	**-0.97**	-0.85
FIN	0.43	**0.87**	1.07	0.39	**0.85**	1.07	0.21	**0.59**	1.03	0.36	**0.76**	1.04	-0.52	**-0.23**	0.04
FRA	0.50	**1.02**	1.09	0.59	**1.03**	1.12	0.12	**0.56**	1.03	0.13	**0.48**	0.95	-0.14	**0.13**	0.41
GER	-0.32	**0.38**	1.06	-0.20	**0.39**	1.04	-0.52	**0.07**	0.65	-0.24	**0.23**	0.71	-0.60	**-0.37**	-0.10
GRC	0.32	**0.67**	1.02	0.32	**0.63**	0.96	0.09	**0.41**	0.80	0.33	**0.72**	1.05	-1.00	**-0.86**	-0.71
IRL	0.17	**0.62**	1.04	0.33	**0.78**	1.06	0.11	**0.51**	1.02	0.23	**0.60**	1.02	-0.16	**0.11**	0.38
ITA	-0.07	**0.62**	1.08	-0.09	**0.56**	1.06	-0.28	**0.17**	0.69	-0.35	**0.00**	0.33	-0.05	**0.19**	0.47
NLD	0.41	**1.01**	1.09	0.71	**1.04**	1.27	-0.14	**0.40**	1.03	0.12	**0.56**	1.03	-0.50	**-0.22**	0.04
PRT	0.37	**1.02**	1.09	0.46	**1.02**	1.14	-0.07	**0.44**	1.03	0.09	**0.55**	1.03	-0.89	**-0.70**	-0.50

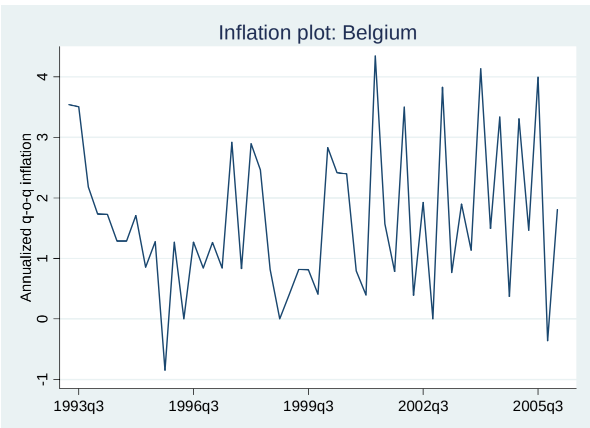
Appendix 3: Inflation plots for selected countries.

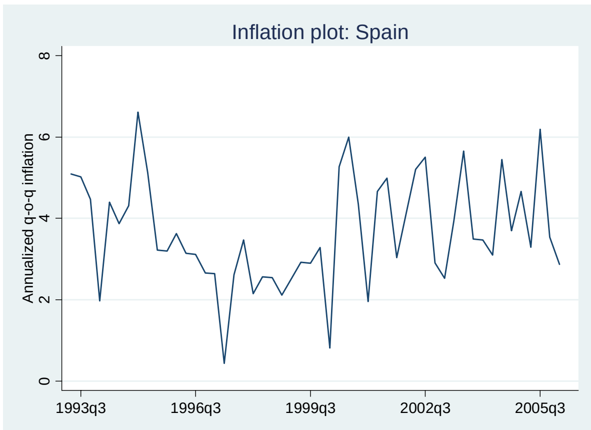


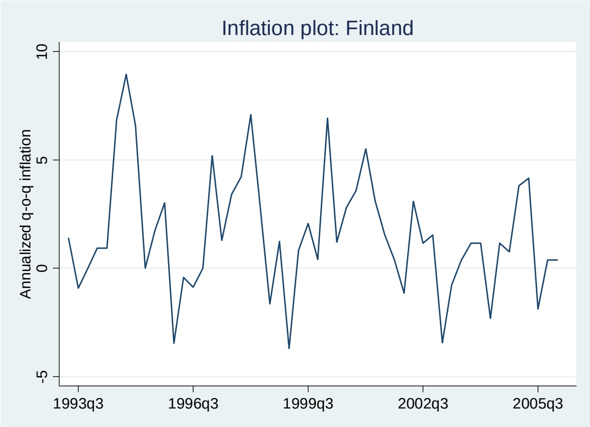


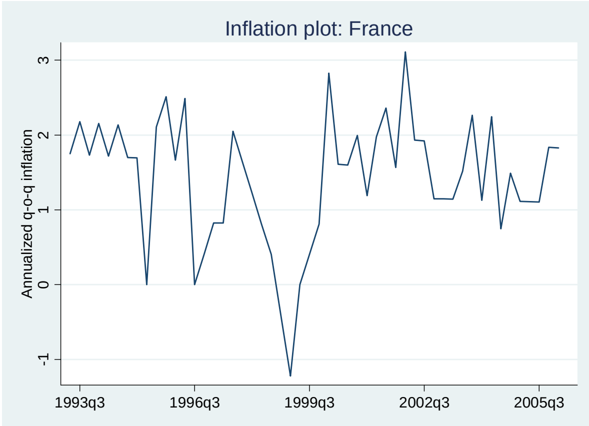


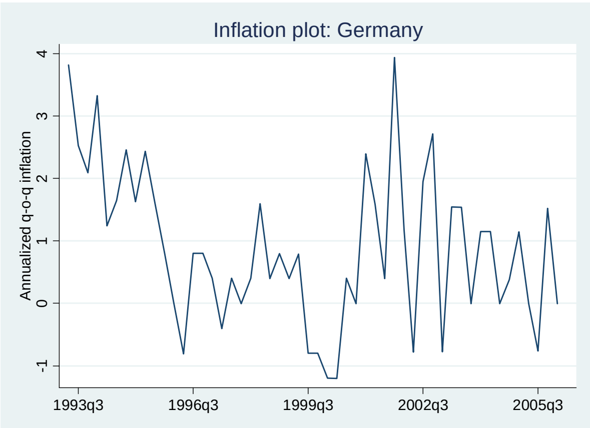


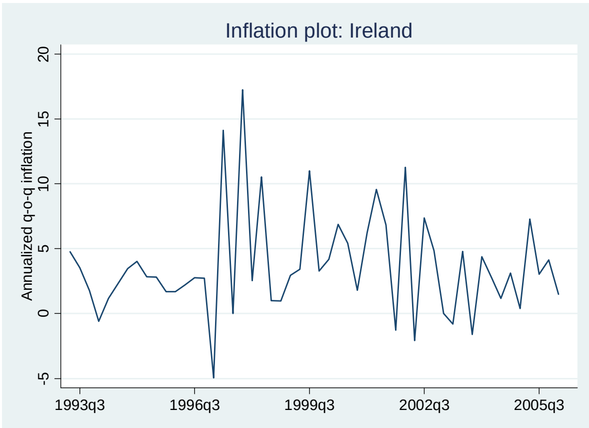


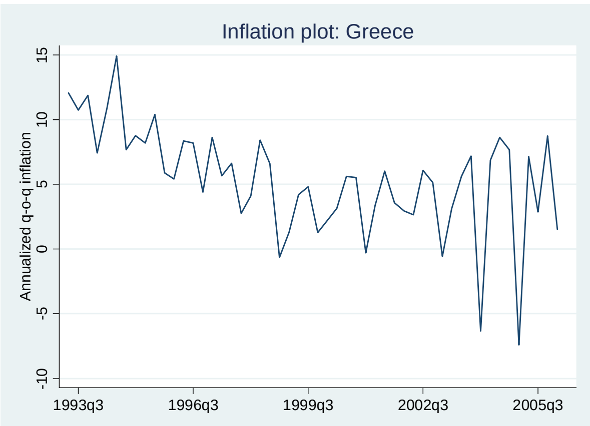


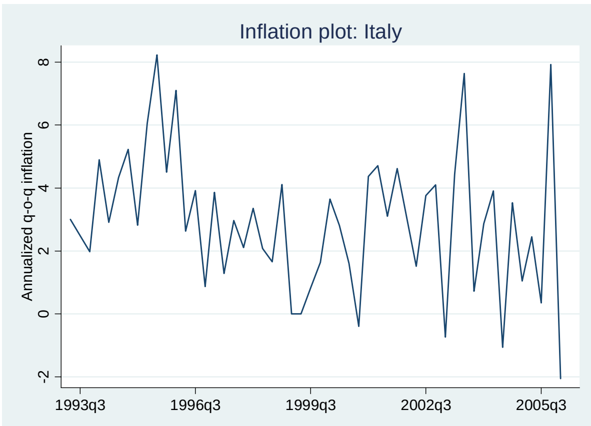

Inflation plot: Finland
Annualized q-o-q inflation
1993q3
1996q3
1999q3
2002q3
2005q3

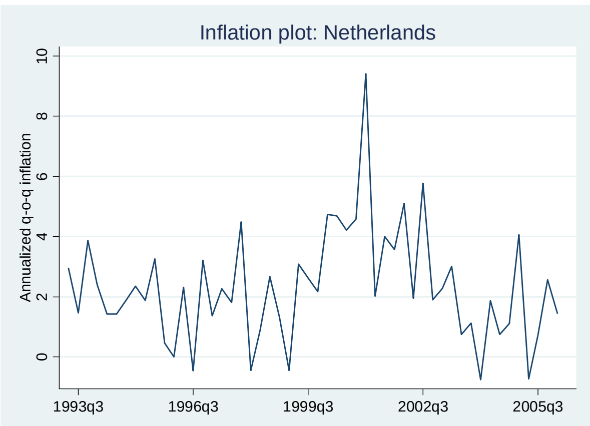

Inflation plot: France
Annualized q-o-q inflation
1993q3
1996q3
1999q3
2002q3
2005q3

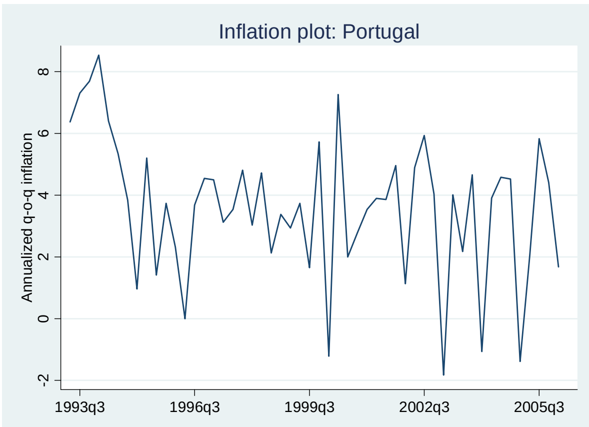

Inflation plot: Germany
Annualized q-o-q inflation
1993q3
1996q3
1999q3
2002q3
2005q3


Inflation plot: Ireland
Annualized q-o-q inflation
1993q3
1996q3
1999q3
2002q3
2005q3


Inflation plot: Greece
Annualized q-o-q inflation
1993q3
1996q3
1999q3
2002q3
2005q3


Inflation plot: Italy
Annualized q-o-q inflation
1993q3
1996q3
1999q3
2002q3
2005q3


Inflation plot: Netherlands
Annualized q-o-q inflation
1993q3
1996q3
1999q3
2002q3
2005q3


Inflation plot: Portugal
Annualized q-o-q inflation
1993q3
1996q3
1999q3
2002q3
2005q3