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By **SYLVESTER C.W. EIJFFINGER and QIAN ZONGXIN***

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Abstract

A cross-country parameter homogeneity assumption is usually imposed in the literature to test the effect of trade openness on the slope of the Phillips curve. A conclusion from this literature is that trade openness has no significant effect in advanced industrial countries. In this paper, we argue that the validity of the parameter homogeneity assumption is not guaranteed from a theoretical perspective, and we find that this assumption is not valid for advanced industrial countries. Trade openness has significant effects on the slope of the Phillips curve in several industrial countries but the signs of the effects vary across countries.

JEL Classification: E31, E52, F41

Keywords: Openness, Phillips Curve, Heterogeneity

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1. Introduction

Due to differences in modeling strategies and behavioral assumptions, previous theoretical models on the trade openness-Phillips curve correlation give different predictions on the effect of trade openness on the slope of the Phillips curve. Models of Romer (1993) and Lane (1997) predict that an increase in trade openness steepens the Phillips curve, while models of Razin and Loungani (2005) and Daniels and VanHoose (2006) predict that an increase in trade openness flattens the Phillips curve. As a consequence, previous cross-country empirical studies (Badinger, 2009; Daniels, Nourzad, & Vanhoose, 2005; Daniels & VanHoose, 2009; Temple, 2002) use the sign and statistical significance of estimated trade openness-Phillips curve correlation to test the empirical relevance of various theoretical models. In those cross-country studies, parameters of the regression equation are assumed to be homogeneous across countries. Other authors (Ball, 2006; Ihrig, Kamin, Lindner, & Marquez, 2010; IMF, 2006) who use panel data methods to test the trade openness-Phillips curve correlation make the the same assumption. With the parameter homogeneity assumption, those studies find that trade openness has no significant impact on the slope of the Phillips curve in industrial countries.

However, a recent theoretical study by Sbordone (2007) finds that the net effect of a change in the degree of trade openness on the slope of the Phillips curve is ambiguous, depending on the relative changes in the steady-state price elasticity of demand, elasticity of the representative firm's desired markup to its market share, elasticity of the firm's marginal cost to its own output after a change in trade openness. The net effects of trade openness on the slope of the Phillips curve will differ in size and/or sign across countries if those relative changes after a change in trade openness differ across countries, which implies that a parameter homogeneity restriction in the econometric analysis is potentially problematic.

In this paper, we test the parameter homogeneity assumption in a panel data setting. Our results show that the parameter homogeneity assumption does not hold. Allowing parameters to be heterogeneous across countries, we find that trade openness has significant impacts on the slope of the Phillips curve in several major industrial countries (Canada, France, Italy, Sweden and the United States), but the impacts vary in sign across countries.

The paper proceeds as follows. Section 2 introduces the empirical model and the data. Section 3 tests the parameter homogeneity assumption in a panel data setting. Section 4 studies the slope of the Phillips curve in the sample countries using country-specific time series analysis. Section 5 concludes.

2. The empirical model and data description

As surveyed by Gordon (2011), there is a debate on the empirical modeling of inflation expectations. Some economists assume that agents are backward-looking while others use a forward-looking assumption. We adopt the backward-looking assumption because the estimation of the forward-looking model involves instrumental variables and the results are subject to weak instrument problems (Kleibergen & Mavroeidis, 2009; Nason & Smith, 2008). The focus of this paper is on the validity of the parameter homogeneity assumption in the previous empirical models. Hence, it is better to separate the focus issue from the instrument quality issue.

Moreover, previous studies (Ball, 2006; Ihrig et al., 2010; IMF, 2006) on the openness-Phillips curve correlation typically adopt the backward-looking assumption. Therefore, it is easier to compare the results if we use the same assumption. More specifically, our econometric analysis is based on the following backward-looking Phillips curve model:

$$\pi^c_{i,t} = \delta_{0i} + \delta_{1i}\pi^c_{i,t-1} + \delta_{2i}\hat{y}_{i,t} + \delta_{3i}\alpha_{i,t}\hat{y}_{i,t} + \tau'_{i1}X_{i,t} + \tau'_{2i}W_{i,t} + \varepsilon_{it}, \quad (1)$$

where i is the index for country i=1,.. .,N, t=1,.. .,T is the index for time, $\pi^c_{i,t}$ is the core consumer price index (CPI) inflation rate; $\alpha_{i,t}$ is the trade openness measured as total imports and exports divided by GDP; $\hat{y}_{i,t}$ is the output gap; $\delta_{0i}, \delta_{1i}, \delta_{2i}$ and δ_{3i} are parameters; τ_{i1} and τ_{i2} are vectors of parameters; the vector $X_{i,t}$ contains the cost-push terms, $W_{i,t}$ contains the control variables and ε_t is the error term.

We consider three cost push terms, $p^e_{it}, p^f_{it}, p^m_{it}$, which are the deviations of energy, food, import price changes from the last-period core CPI inflation rate, respectively. Following Ihrig et al. (2010), we also add the interaction term $p^m_{it} * Mshare_{it}$ as an additional indicator for the cost push. $Mshare_t$ is import as a share of GDP. There is also debate on whether or not one should include the cost push terms into the empirical model. Ball (2006) argues that those terms should not be included in the Phillips curve estimation. This argument is rooted in the theoretical model of Ball and Mankiw (1995) in which smooth relative price changes, such as smooth changes in the price of energy, food and import goods relative to the general price level, do not affect the general price level. The empirical validity of that model, however, is challenged by Bryan and Cecchetti (1999). Gordon (2011) justifies the role of relative price changes by price rigidity in sectors which are not subject to the relative price shocks. Monacelli (2005) suggests that in an open economy with incomplete exchange rate pass-through, additional cost-push terms must be added to the Phillips curve if the output gap is used to measure the log deviation of real marginal cost. Batini, Jackson, and Nickell (2005) suggest that the signs of the cost-push terms in the Phillips curve can be either positive or negative, depending on the elasticity of material inputs with respect to gross output. Due to the theoretical ambiguity, we do not impose any sign or size restriction on the cost-push terms and will apply the general-to-specific model selection strategy to eliminate redundant variables when estimating the slope of the Phillips curve.

Our set of control variables include financial openness*output gap, log GDP*output gap, log population*output gap, trend inflation*output gap and global inflation. Theoretical models of Loungani, Razin, and Yuen (2001); Razin and Yuen (2002),and Razin and Loungani (2005) suggest that besides trade openness, financial openness could also affect the slope of the Phillips curve. Badinger (2009) shows that omitting the interaction between the degree of financial openness and the output gap in the regression can cause an endogeneity problem. More specifically, trade and financial openness are highly correlated. If both have significant effects on the slope of the Phillips curve, omitting one of them will cause an omitted variable bias.

Previous literature, for example, Lane (1997), argues that country size could affect the slope of the Phillips curve. Because openness is correlated to country size (Lane, 1997), omitting country size could lead to an estimation bias. While Lane (1997) uses a country's GDP as a proxy for the country size, Badinger (2009) uses population as an alternative proxy. We use both as candidate proxies for the country size and use the general-to-specific model selection strategy to decide whether those control variables should stay in the model. The state-dependent pricing model of Bakhshi, Khan, and Rudolf (2007)) suggests that trend inflation affects the slope of the Phillips curve. An early empirical study of Ball, Mankiw, and Romer (1988) made a similar argument. Therefore, we follow them to control for the impact of trend inflation (which is measured as the HP-filtered trend of core inflation rate). Our last control variable is the "global inflation" variable defined by Ciccarelli and Mojon (2010). These authors find that there is a common factor in the OECD countries' national inflation rates and they call this common factor "global inflation". Ciccarelli and Mojon (2010) suggest that a simple cross-country average of 22 OECD countries[1] fits the "global inflation" well, so we follow them and proxy global inflation by the simple cross-country average of the 22 OECD countries.

We use similar data source as Ihrig et al. (2010). However, the frequency of our model is annual rather than quarterly because one important control variable, financial openness, is sampled at the annual frequency. As we shall see, financial openness has significant impacts on the slope of Phillips curve in some sample countries. Since it is highly correlated with trade openness, omit-ting it will cause estimation bias. It can be shown that the differences in results between our model and the model of Ihrig et al.(2010) do not come from the difference in sampling frequency but come from the differences in model specifications.[2]

The sample period is 1977-2007, which covers the sample period of Ihrig et al. (2010), 1977-2005. The Ihrig et al. (2010) sample consists of eleven OECD countries. Our sample takes nine out of these eleven countries. Ihrig et al. (2010) measure the output gap of the sample countries by the OECD output gap estimates. When the OECD output gap estimates are missing, as is the case for Switzerland, they use the Hodrick and Prescott (HP) filtered output gap instead. We only include countries with the OECD output gap estimates in our sample for consistency reasons.[3]

Data on core CPI inflation, total import, output gap, energy price, food price and import price are taken from the OECD main economic indicators No. 87. Data on trade openness is taken from the Penn World Table. Nominal GDP, real GDP and population data are retrieved from the World Development Indicators database. Following Badinger (2009), we define the degree of financial openness as total foreign assets and liabilities divided by GDP. The data used to construct the financial openness measure are from the updated and extended version of the External Wealth of Nations Mark II database developed by Lane and Milesi-Ferretti (2007).

3. Test the parameter homogeneity restriction in a panel data setting

It is well-known that panel data analysis may be potentially efficiency-improving since it imposes a structure, which is extra information, on the regression. However, one has to be aware that the estimates will be biased if a false structure is imposed. Ihrig et al. (2010) and Ball (2006) estimate the effect of trade openness on the slope of the Phillips curve in panel data models. Their panel data models are estimated with the assumption that the coefficients of the explanatory variables are the same across countries. This assumption is also imposed in cross-country studies on the same topic. In this section, we formally test this assumption.

To see this, consider the panel data model in Eq. (1). This model nests the panel data models of Ihrig et al. (2010) and Ball (2006) as special cases. More specifically, Ihrig et al. (2010) estimate a model with $\tau 2=0$, and Ball (2006) estimates a model with

[1] The 22 OECD countries are Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Luxembourg, New Zealand, Norway, Portugal, Sweden, Switzerland, Spain, United Kingdom, United States, and the Netherlands.

[2] Using the same specification as Ihrig et al. (2010), we obtain the same qualitative results as theirs. The results are available upon request.

[3] Our key results are robust if we use the HP filtered output gap to replace the OECD output gap. The results are available upon request.

$\tau1=\tau2=0$. We perform the Roy-Zellner poolability test (Baltagi, 2005) for Eq. (1). The null hypothesis of the Roy-Zellner test is that the cross-section units can be pooled. The test statistics follow an F-distribution with ((N-1)K′ ,N(T-K′)) degrees of freedom, where N is the number of cross-section units, T is the number of time periods, K′ =K+1,K is the number of explanatory variables. The test statistics is 188.47, the p value is 0.00. Therefore, the null assumption of poolability is clearly rejected. We further test the assumption that the coefficients of the interaction term between openness and the output gap are homogeneous across countries, allowing other parameters to be heterogeneous. Again the assumption is rejected at the 5% level (the test statistics is 17.89 and the p value is 0.02).

In sum, the parameter homogeneity assumption on the parameter of interest is rejected by our panel data model, which suggests that results from previous empirical studies with the parameter homogeneity assumption are not robust. A typical fixed effects model controls for the heterogeneity in the intercepts, but still omits the heterogeneity in the slopes. Therefore, it will generate biased results when trade openness has heterogeneous effects across countries. Note that controlling for the potential omit-ted variable bias is important for the poolability test. If we omit the vector $W_{i,t}$ from Eq. (1), the null of parameter homogeneity cannot be rejected (the p value is 0.68). However, variables in $W_{i,t}$ are jointly significant at the 1% level (the Wald test statistics is 155.06 and the p value is 0.00). This result suggests that it is important to include the additional control variables.

4. Country-specific time series analysis

In the previous section, we find that our sample countries are not poolable as a homogenous panel. Therefore, we estimate the slope of the Phillips curve using country-specific time series analysis.[4]

Benati (2008) argues that the impact of past inflation on current inflation may have changed over time due to institutional changes. We use the Andrews (1993) test to check for potential structural breaks in the impact of past inflation on current inflation of the sample countries. Even if we have prior expectations that some events may change the process of inflation, how long does it take for the effects of the events to be fully absorbed is uncertain. The advantage of the Andrews (1993) test over the standard Chow test is that it does not require us to specify an arbitrary year for the structural break.[5] Therefore, it avoids the bias from a misspecified break point. Compared to a Chow test with correctly specified structural breaks, the Andrews (1993) test is less efficient. To test the robustness of results, we perform the Chow test with break points detected by the Andrews (1993) test. The results are consistent with the Andrews (1993) test results. In six out of nine countries, i.e., Australia, Canada, France, The Netherlands, Sweden, United States, we find a significant structural break. This suggests that we need to model the potential structural break to get the right inference.

Our modeling strategy is as follows: we always include a constant term, lagged core inflation rate, the output gap and the interaction term between trade openness and the output gap in the model as our focus variables. Other variables are taken as control variables in the model. We remove them from the model if they are detected to be redundant by the F-test. We introduce an interaction term between a break dummy and the lagged dependent variable into the model whenever a structural break is

[4] Our main results are robust if we estimate the model with all sample countries using seemingly unrelated regression. The estimation results are available upon request.

[5] An alternative to the Andrews test is the Chow forecast test of stability.

identified by the Andrews (1993) test. Moreover, we eliminate outliers from the model by adding dummy variables which take the value one in the outlier year and zero otherwise.[6]

Table 1
Estimation results (without control for financial openness).

Explanatory variable	Australia	Canada	France	Italy	Japan	Netherlands	Sweden	UK	US
Constant	2.62**	0.63	−0.29	−0.17	0.18	0.44	−0.98	−1.35**	0.50**
	(0.62)	(0.37)	(0.17)	(0.46)	(0.18)	(0.23)	(0.53)	(0.47)	(0.15)
Lagged core inflation	0.64**	0.46**	0.68**	0.44**	0.75**	0.58**	0.34*	0.09	0.67**
	(0.08)	(0.16)	(0.09)	(0.18)	(0.05)	(0.10)	(0.15)	(0.14)	(0.06)
Lagged core inflation*break dummy	−0.57**	−0.26*							−0.14**
	(0.16)	(0.10)							(0.03)
Output gap	2.12*	1.24**	310.76**	203.43*	−0.21	0.21	1.46**	−0.89	−85.53
	(0.03)	(0.29)	(53.01)	(85.89)	(0.43)	(0.30)	(0.51)	(1.67)	(73.94)
Trade openness*output gap	−5.37	−1.59**	10.24**	11.64	1.63	0.11	−1.41	1.11	−8.55
	(3.43)	(0.56)	(2.30)	(6.92)	(2.33)	(0.32)	(0.81)	(3.67)	(7.86)
Energy price			−0.03*						
			(0.02)						
Food price			0.12*				−0.27**		
			(0.05)				(0.08)		
Import price							0.23**		
							(0.07)		
Import price*import share									
Log population*output gap			−28.63**						−13.27**
			(4.90)						(3.58)
Log GDP*output gap				−7.57*					8.47**
				(3.22)					(2.11)
Trend inflation*output gap								0.23**	0.41**
								(0.06)	(0.12)
Global inflation		0.42**	0.27**	0.71*		0.12*	0.79**	1.20**	0.22**
		(0.14)	(0.09)	(0.32)		(0.06)	(0.18)	(0.19)	(0.05)
Outlier dummy				5.57**	2.34**			−5.03**	2.81**
				(0.78)	(0.68)			(1.27)	(0.43)
Adjusted R-squared	0.80	0.94	0.99	0.98	0.92	0.84	0.88	0.94	0.99
Normality	0.97	0.82	0.22	0.69	0.31	0.25	0.50	0.93	0.77
Serial correlation	0.29	0.09	0.80	0.22	0.66	0.84	0.54	0.31	0.39
Arch	0.59	0.07	0.34	0.16	0.89	0.60	0.84	0.68	0.43
Redundancy	0.58	0.76	0.25	0.87	0.19	0.08	0.35	0.74	0.30

Notes: The dependent variable is the core inflation rate of the respective country. Standard errors in parentheses. *, ** denotes statistical significance at 5% and 1% level. Energy price, food price and import price stand for the deviations of the change of these prices from last period's core CPI inflation rate. Normality: Jarque-Bera test *p* values. Serial correlation: LM test *p* values for serial correlation up to two orders. Arch: test *p* values for Arch(1). Redundancy: F test *p* values for redundancy. Outlier years: Italy (1979–1980), Japan (1980), the UK (1978), and the US (1984).

Most previous studies on openness and the slope of the Phillips curve consider only trade openness while Badinger (2009) argues that financial openness is also important and omitting it in the regression analysis biases the estimated coefficient of trade openness. In this paper, we present two versions of model specifications. One does not consider the impact of financial openness, and the other includes an interaction term between financial openness and the output gap. As noted by Badinger (2009), trade and financial openness are highly correlated. This can cause a collinearity problem in the estimation. Following Badinger (2009), we estimate the model with the restriction that the coefficient of trade openness*output gap is the same as financial openness*output gap. Formal statistical tests (Table 2) support the restriction in seven out of the nine sample countries. The restriction is rejected in France and Sweden. For those two countries, we report the estimation results without the restriction (in Table 2).

The results of those two alternative specifications are reported in Tables 1 and 2 respectively. From those two tables, we see that the estimated coefficients of our variable of interest, the interaction term between trade openness and the output gap, differ in sign across countries. Without a control for the impact of financial openness, the interaction term between trade openness and the output gap is statistically significant in two of the major industrialized countries, that is, Canada and France. More specifically, the estimated coefficient of the interaction term between trade

[6] See the table notes for the detected outlier years.

openness and the output gap is negative in Canada, suggesting that trade openness flattens the Phillips curve. By contrast, there is a steepening effect of trade openness in France. Controlling for financial openness makes trade openness significant in more sample countries. More specifically, according to the results in Table 2, trade openness has significantly affected the slope of the Phillips curve in Canada, France, Italy, Sweden and the US.[7] The qualitative findings on the trade openness-Phillips curve correlations remain the same for Canada and France whether or not financial openness is controlled for. Moreover, in the model with financial openness, trade openness has a significant flattening effect on the Phillips curve in Sweden and the US while it has a significant steepening effect in Italy.

Table 2
Estimation results (with control for financial openness).

Explanatory variable	Australia	Canada	France	Italy	Japan	Netherlands	Sweden	UK	US
Constant	2.71**	0.64	−0.26	−0.25	0.21	0.54**	−1.04	−1.36**	0.50**
	(0.61)	(0.37)	(0.14)	(0.38)	(0.15)	(0.20)	(0.50)	(0.49)	(0.15)
Lagged core inflation	0.63**	0.41**	0.63**	0.45**	0.69**	0.72**	0.40**	0.08	0.68**
	(0.08)	(0.15)	(0.07)	(0.16)	(0.06)	(0.06)	(0.15)	(0.14)	(0.06)
Lagged core inflation*break dummy	−0.58**	−0.24*							−0.13**
	(0.16)	(0.10)							(0.03)
Output gap	1.45**	1.21**	255.29**	604.71**	−0.46	0.10	5.10*	−0.59	−130.45**
	(0.49)	(0.28)	(49.11)	(158.96)	(0.31)	(0.14)	(1.99)	(0.94)	(21.87)
Trade/financial openness*output gap	−0.72	−0.43**		1.66**	0.47	0.03		0.04	−0.89**
	(0.43)	(0.15)		(0.48)	(0.26)	(0.03)		(0.16)	(0.22)
Trade openness*output gap			14.35**				−10.76*		
			(4.68)				(5.02)		
Financial openness*output gap			−0.51				1.10		
			(0.32)				(0.59)		
Energy price			−0.03*						
			(0.01)						
Food price			0.15**				−0.30**		
			(0.04)				(0.08)		
Import price							0.28**		
							(0.08)		
Import price*import share									
(Log GDP-Log population)*output gap									7.55**
									(1.27)
Log population*output gap			−23.64**						
			(4.56)						
Log GDP*output gap				−23.23**					
				(5.76)					
Trend inflation*output gap				−0.44**				0.22**	0.53**
				(0.13)				(0.06)	(0.08)
Global inflation		0.45**	0.30**	0.74**			0.75**	1.21**	0.21**
		(0.14)	(0.08)	(0.27)			(0.17)	(0.20)	(0.05)
Outlier dummy			1.50**	5.45**	2.94**	2.33**		−5.01**	2.54**
			(0.46)	(0.64)	(0.74)	(0.59)		(1.27)	(0.37)
Adjusted R-squared	0.80	0.94	0.99	0.98	0.92	0.88	0.89	0.94	0.99
Normality	0.98	0.86	0.68	0.41	0.13	0.62	0.85	0.92	0.77
Serial correlation	0.38	0.15	0.32	0.28	0.60	0.99	0.78	0.35	0.93
Arch	0.47	0.07	0.23	0.35	0.94	0.96	0.91	0.76	0.48
Redundancy	0.59	0.74	0.10	0.86	0.27	0.50	0.31	0.71	0.20
Restriction	0.67	0.65	0.01**	0.70	0.30	0.79	0.05*	0.81	0.10

Notes: The dependent variable is the core inflation rate of the respective country. Standard errors in parentheses. *, ** denotes statistical significance at 5% and 1% level. Energy price, food price and import price stand for the deviations of the change of these prices from last period's core CPI inflation rate. Normality: Jarque-Bera test *p* values. Serial correlation: LM test *p* values for serial correlation up to two orders. Arch: test *p* values for Arch(1). Redundancy: F test *p* values for redundancy. Restriction: F test *p* values for the parameter restriction on financial openness*output gap. Outlier years: France (1980), Italy (1979–1980), Japan (1980), the Netherlands (1980), the UK (1978), and the US (1984).

5. Conclusion

In this paper, we argue that the typical assumption of parameter homogeneity used in the empirical studies of the trade openness-Phillips curve correlation is not guaranteed to be valid from an ex ante theoretical perspective. We test this assumption with both panel data and time series analysis. Our results suggest that the validity of the parameter homogeneity assumption is highly questionable. When the parameter homogeneity assumption does not hold, reporting an average effect of trade openness on the slope of the Phillips curve can be very misleading. Significant effects with

[7] Note that for the United States, the restriction that the coefficients of log GDP*output gap and log Popluation*output gap are the same in magnitude but different in sign cannot be rejected (the p value of the test is 0.69). Therefore, the US model reported in Table 2 is estimated with this restriction.

different signs can be averaged out while trade openness has indeed played a role in all sample countries. Relaxing the parameter homogeneity assumption, we find that trade openness has significantly changed the slope of the Phillips curve in several major industrial countries. In our model with both trade and financial openness, a significant effect of trade openness is found in Canada, France, Italy, Sweden and the United States.

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