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Originally published as:

Schwerhoff, G., Sy, M. (2014): The non-monetary side of the global disinflation. - Open Economies Review, 25, 2, 337-371

DOI: [10.1007/s11079-013-9283-7](https://doi.org/10.1007/s11079-013-9283-7)

Available at <http://link.springer.com>

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The Non-Monetary Side of the Global Disinflation *

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May 2013

Abstract

The dramatic decline in inflation across the world over the last 20 years has been largely credited to improved monetary policy. The universal nature of the phenomenon, however, indicates that globalization, which occurred simultaneously, also played a role. We build a model based on [Melitz \(2003\)](#) in which falling transport cost lead to greater openness, higher productivity and lower inflation. Following a decline in transport cost openness increases and firm selection eliminates the least productive domestic firms. The consequent increase in average productivity leads to falling relative prices for goods. A cash-in-advance constraint allows analyzing how falling relative prices can lead to lower inflation. Using a data set of macroeconomic variables for 123 countries from all world regions, we disentangle the influences of monetary policy and globalization by showing that openness-induced productivity growth leads to a significant decline in inflation world-wide. The results can be further confirmed in a calibration exercise.

JEL classification: F15, F41, E31

Keywords: Globalization, openness, monetary policy, productivity, disinflation

*The authors wish to thank the editor George Tavlas and two anonymous referees for very helpful remarks and suggestions. They thank also François Bourguignon, Vasco Carvalho, Daniel Cohen, Mathieu Couttenier, Martin Hellwig, Jean Imbs, Alberto Martin, Romain Rancière, Hamidreza Tabarraei and Mirko Wiederholt for helpful comments. We are grateful to Ayhan Kose, Eswar S. Prasad and Marco E. Terrones for sharing their data. We also thank seminar participants at Universidad Pompeu Fabra, University of Bonn, CGSP, CEPII, and Paris School of Economics. Conference participants at the 19th Conference on New Challenges for Macroeconomic Policy, Marseille; the 6th PhD Presentation Meeting of the Royal Economic Society, London; the Annual Conference of the Royal Economic Society, Cambridge; the 60th Congress of the French Economic Association, Paris; the 15th Conference on Theory and Method in Macroeconomics, Montreal; the 26th Congress of the EEA, Oslo. This research was conducted while the authors were visiting UPF, Barcelona. Mouhamadou Sy gratefully acknowledges financial support from the Region Ile-de-France and the Cepremap.

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1 Introduction

The fact that inflation has fallen everywhere - even in countries with weak institutions, unstable political systems, thinly staffed central banks, etc. - invites us to open our minds to the possibility that other factors have also been significant. Kenneth S. Rogoff, (2003)

During the early 1990s, the world-wide patterns of openness to trade and inflation have changed dramatically. All regions of the world increased their openness to trade strongly increasing the world average from 39% in 1990 to 54% in 2005. In a parallel development, inflation saw an even more dramatic change, decreasing from a world average of 26% in 1990 to only 3.8% in 2005. As [Rogoff \(2003\)](#) points out, a number of possible approaches can explain this fall in inflation, among them improved monetary policy, technological development and globalization. We argue in this paper that globalization in the form of increasing openness to trade is a driving force of falling inflation.

Transport cost have decreased strongly since 1990. A table published by the World Bank shows a decrease in unweighted average tariff rates from 23.9% in 1990 to 8.6% in 2009, see [World Bank \(2009\)](#).¹ The subsequent reallocation of production has an obvious effect on openness, defined as imports plus exports over GDP. Since consumers like variety and firms diversify their inputs (see [Marin \(2006\)](#)), more products from abroad are imported. As falling transport cost allow more home producers to export, imports and exports increase.

More openness increases competition. The empirical and theoretical literature ([Pavcnik \(2002\)](#), [Bernard et al. \(2003\)](#), [Syverson \(2004\)](#), [Bernard et al. \(2006\)](#)) shows that this increase in competition forces the least productive firms out of the market and production is reallocated towards more productive firms. Industries, even if narrowly defined, show a large variety of productivity. When competition increases, the least productive firms can no longer make positive profits and have to quit the market.

Inflation is affected via productivity. As more trade increases competition, some firms that could operate profitably in a more closed market are no longer able to do so. They have to

¹All tariff rates are based on unweighted averages for all goods in ad valorem rates or applied rates or MFN rates whichever data is available in a longer period.

stop production and leave the market. As a consequence, average productivity in the economy increases. This in turn leads to lower average prices which reduces inflation. In addition, more open countries consume more goods from abroad which reduces average consumption prices since only the most productive foreign firms export.

Productivity and its reaction to transport cost play a vital role in this concept. So we use the framework of [Melitz \(2003\)](#) where productivity is endogenously determined. We modify it to analyze the interaction of productivity with openness and inflation.

[Romer \(1993\)](#) finds that openness and inflation are negatively related. This is based on [Rogoff \(1985\)](#) who finds that a surprise monetary expansion causes the real exchange rate to depreciate and that the depreciation is larger in more open economies. The same amount of inflation will thus require a larger monetary expansion in a more open economy. The Central Bank of a more open economy thus has a lower incentive to create a surprise inflation. [Rogoff \(2003\)](#) also finds the incentive structure for the central bank to provide the link between globalization and disinflation. His argument however is that more competition from abroad makes prices and wages more flexible.

[Chen et al. \(2004\)](#) investigate the effect of increased trade on prices, productivity and markups in the EU. Inter alia, they find that for the period 1988 to 2000 increased openness in the EU reduced inflation. Similarly, [Chen et al. \(2009\)](#) estimates a version of [Ottaviano and Melitz \(2008\)](#) and obtain directly estimable equations. So these papers find the same qualitative results but focus on one world region, the European Union, for which they are able to use disaggregated data on the manufacturing sectors.

The effect of openness on inflation has been investigated in the framework of the New Keynesian Phillips Curve (NKPC) by [Woodford \(2007\)](#), [Sbordone \(2007\)](#), [Calza \(2009\)](#), [Milani \(2010\)](#), [Martinez-Garcia and Wynne \(2010\)](#) and [Barthelemy and Cleaud \(2011\)](#) for example. This literature aims at finding a permanent effect of openness on inflation through a structural change in the economy, notably the Phillips Curve. Finally, there are papers such as [Auer and Fischer \(2010\)](#) which quantify the effect of low-price imports on the inflation of individual countries.

On the theoretical side, our contribution is the modification of the Melitz model with mon-

etary variables. In addition, we decompose productivity into two driving factors, openness-induced and “normal” productivity growth. Using the empirical plausibility for the Pareto distribution in firm productivity levels provided by [Luttmer \(2007\)](#), we use this distribution to get specific predictions from the model concerning the effect of globalization. Using a cash-in-advance constraint, we obtain an *extended* quantity equation which identifies the effect of openness on inflation via productivity. This provides an alternative perspective to the NKPC literature on the nexus of globalization and inflation. Unlike the NKPC literature, the effect described here is transitory and affects inflation as long as openness keeps increasing. This has necessarily different policy implications.

While the empirical literature explores the monetary side as well as productivity, markups and import prices on the real side as causes of disinflation, none of the studies above attempts to answer to Rogoff’s challenge to explain disinflation *worldwide*, including countries with “thinly staffed central banks”. This paper links productivity and a precise measure of globalization to inflation using a macroeconomic dataset of 123 countries from all world regions. It attempts to shed light on the concentration of the cross-country distribution of inflation rates around 3 percent, in other words on the global dimension of global disinflation.

We will illustrate our thesis of a fundamental and important link between trade globalization and global disinflation in four steps. Section 2 will give an intuitive approach, illustrating the astounding co-movement between openness and inflation and its context graphically as well as in descriptive statistics. Section 3 provides a theory which informs us on why we should expect a strong link between openness and inflation. Section 4 describes a calibration exercise of the effect of transport cost on productivity and inflation. Section 5 explores causality with a detailed econometric analysis. Section 5 concludes.

2 Descriptive Evidence

Economists are largely familiar with the general phenomenon of globalization and disinflation. In this section, we pin down these phenomena in time and describe a number of details which are much less well-known. First, all world regions are affected so the development is

not driven only by a few economic “heavyweights”. Second, the change occurs continuously over the entire period of 1990 to 2010, there is no jump in levels. Third, the year 1990 marks a true turning point for the growth rate of both variables, suggesting a strong interaction.

One of the most important manifestations of globalization is trade openness. Since the early 1990s, there has been a rapid trend towards more trade. As Table 1 illustrates, openness as measured as (import plus export)/GDP has increased by almost 16 percentage points in the 15 years to 2005, reaching 54%. This trend has been truly global as it occurred in the developed and developing world climbing steeply in every single continent.

Table 1: Openness, measured as (Import + Export)/GDP

Year	World	Developed	Developing	Asia	Africa	Latin America
1980	38.52	36.00	32.70	33.64	62.65	27.60
1985	37.39	36.32	31.38	33.14	53.76	27.62
1990	38.30	34.90	39.41	47.22	51.76	31.52
1995	42.04	37.35	47.29	58.67	57.61	37.33
2000	49.10	44.87	52.97	66.85	63.20	41.28
2005	54.04	46.41	62.85	86.86	66.64	46.13

Source: World Development Indicators, authors’ calculation

As the sum of imports and exports has climbed quickly, the distribution of imports and exports has also diverged quickly. Open borders have allowed countries to have unbalanced current accounts, a possibility that was used increasingly. Figure 1 shows the cross country distribution of current accounts around the world. In 1980, we still find a sharp peak of current accounts around zero. In the following 10 years, not much changed so that roughly the same pattern can be found in 1990. But as globalization takes hold during the 1990s, a strong trend towards a more dispersed distribution emerges. The peak declines significantly and more mass moves to the tails: The excess supply of goods can flow freely and creates surpluses on the side of exporters (such as China) and deficits on the side of importers (such as the United States). This ultimately exerts a downward pressure on inflation, see the theoretical part. The trend continues well into the 2000s as ever more mass wanders to the tails.

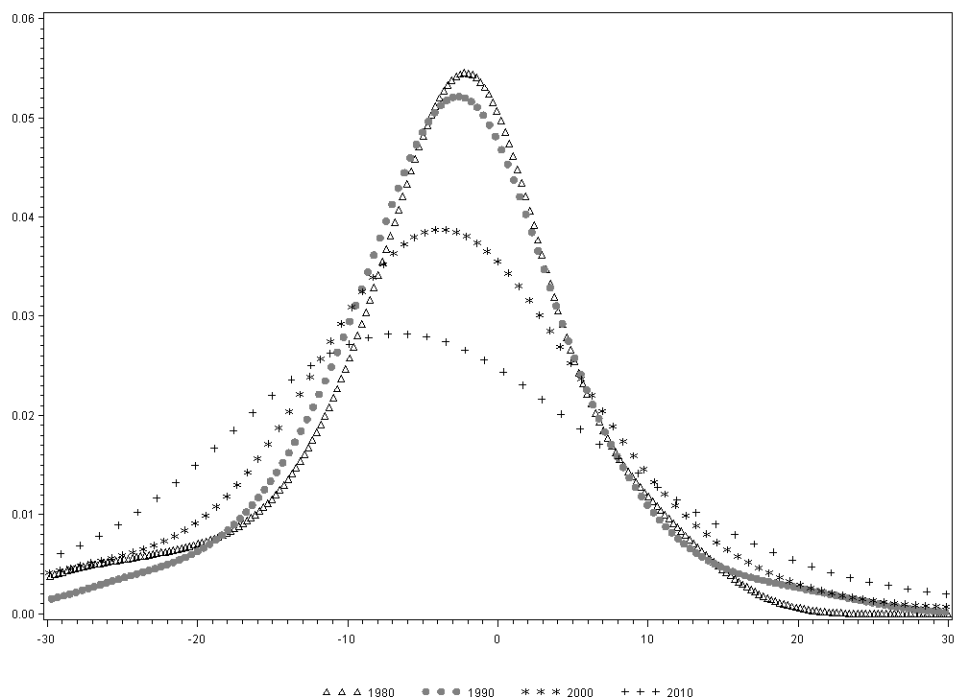


Figure 1: World cross country distribution of current accounts

Kernel density plots of the CA balance of countries without missing data
 Source: World Economic Outlook (IMF) and authors' calculation

A mirror image of this trend is found for inflation, see Table 2. Inflation has decreased world-wide from more than 26% in 1990 to a mere 3.8% in 2005 with most of this drop having occurred in the 1990s. Note that for calculating the average, inflation in each country is weighted by the country's GDP. In developed countries, it was already low in 1990 and has decreased reliably below 3% since 1995. Impressive advances have been made in developing countries where inflation decreased from very high numbers to single-digit values.

Table 2: Inflation (% per year)

Year	World	Developed	Developing	Asia	Africa	Latin America
1980	17.28	12.9	28.30	11.95	16.80	53.76
1985	14.87	5.41	40.92	8.48	12.78	134.1
1990	26.10	5.16	74.27	6.13	13.81	474.1*
1995	14.61	2.63	39.56	12.62	36.25	41.34
2000	4.55	2.24	8.61	1.93	11.78	7.84
2005	3.76	2.22	5.86	3.80	7.11	6.19

Sources: World Economic Outlook (IMF), authors' calculation.

* This figure excludes Argentina and Brazil. Including these two countries gives an even higher value: 1805.24

The disappearance of hyperinflations, especially in Latin America, has to be credited to improved monetary policy. Table 2 therefore reflects two effects on a descriptive basis: The disappearance of very high values of inflation (especially in Latin America after 1990) on the one hand and the universality of the trend to lower inflation on the other hand. These two effects are disentangled theoretically in the next section.

This trend towards lower inflation has given rise to an opposite movement to that found in Figure 1 for openness: The distribution of inflation levels around the world has become increasingly concentrated, see Figure 2. In 1980, the peak of the distribution is well above 10%, with values of more than 20% being no rarity. By 1990, the distribution has shifted to the left with the peak now around 5%. As globalization takes hold, the distribution becomes strongly concentrated around a peak below 3%.

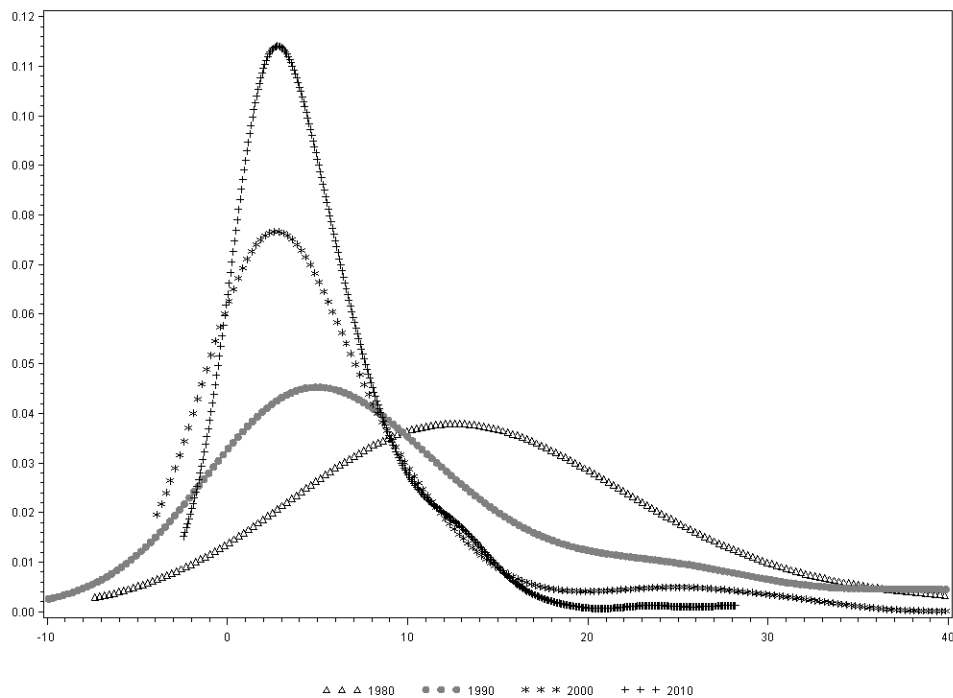


Figure 2: World cross country distribution of inflation
 Kernel density plots of inflation of countries without missing data
 Source: World Economic Outlook (IMF) and authors' calculation

3 The Model

As we laid out in the empirical evidence, openness has an important effect on declining inflation. But what caused openness to rise in the first place? It seems striking that measures of openness show a sudden increase in the early 1990s. A contributing factor might have been technology. It is for example much easier and cheaper to transmit software across large distances than manufactured goods so that the technological revolution of the 1990s facilitated trade. But an even more important development took place on the political side. The balance of payments crisis caused many countries to look for assistance from the Bretton Wood Institutions. These advised and encouraged policies of the *Washington Consensus*, including more openness. This led countries around the world to leave protectionist policies and lower

tariffs. India, as one example, reduced tariff rates from 133 in 1990 to 48 in 1997 as reported in [Aghion et al. \(2008\)](#).

This pattern can best be analyzed in the framework of [Melitz \(2003\)](#). We modified it in a way that clearly highlights how lower transport cost increase openness and how greater openness affects inflation via foreign prices and productivity at home.

After making an investment in sunk entry cost, new firms draw an initial productivity parameter φ from a common distribution. In the model of Melitz, this distribution is not specified. Results are thus kept as general as possible but it also strongly limits the ability of the model to make unambiguous predictions. In order to obtain clear statements on the variables of interest for this paper such as average productivity and prices, we replace the general distribution by the Pareto distribution as in [Ottaviano and Melitz \(2008\)](#), [Ghironi and Melitz \(2005\)](#) and [Helpman et al. \(2004\)](#). [Luttmer \(2007\)](#) provides empirical evidence that the Pareto distribution is a good approximation for firm sizes and thus implicitly for productivity levels.

Using the Pareto distribution, we can analyze the direction of change of the endogenous variables when parameters such as the level of fixed entry costs to the domestic and foreign market or transport cost change. On the side of parameters, we concentrate on changes in transport cost. On the side of the variables, we consider some of those which are already defined in the Melitz paper such as average productivity and price levels. In addition, we define a measure for openness.

We introduce money through a cash-in-advance constraint in order to explicitly analyze the effect of changes in relative prices on the price level. This will provide the link between the immediate real effects of trade and the monetary side.

In this section, we will briefly present the model using the Pareto distribution.

3.1 Setup of the Model

3.1.1 Demand

Utility is given as a CES function. Since each variety is uniquely characterized by the productivity level φ of the producing firm, it can be written as

$$U = \left[\frac{1}{1 - G(\varphi^*)} \int_{\varphi^*}^{\infty} q(\varphi)^\rho N g(\varphi) d\varphi \right]^{\frac{1}{\rho}}, \quad (1)$$

where the elasticity of substitution is given by $\sigma = \frac{1}{1-\rho} > 1$. After paying an initial entry cost, firms draw a productivity distributed by the Pareto distribution

$$g(\varphi) = k \frac{(\varphi_m(t))^k}{\varphi^{k+1}} \quad (2)$$

where $\varphi_m(t)$ is the minimum of productivity draws. But only firms above an endogenous equilibrium cut-off value φ^* are able to stay in the market. (φ^*, ∞) is the interval of producing firms and N indicates the mass of firms and goods. We assume $k > \sigma - 1$ as in [Ghironi and Melitz \(2005\)](#) to assure that the variance of firm size is finite.

The minimum of productivity draws $\varphi_m(t)$ is defined as a function of time. This reflects that the distribution of productivity in an economy changes over time even in the absence of changes in trade volumes. Reflecting the historic trend of increasing productivity, there should be an upward trend in $\varphi_m(t)$. This implies a slow shift of the productivity distribution towards higher productivity. It would be possible at this point to introduce positive and negative productivity shocks, but since the focus of this paper is on long-term trends, we model technological development as a deterministic and exogenous process improving productivity at a constant rate a :

$$\varphi_m(t) = \varphi_{m0} e^{at}. \quad (3)$$

The set of varieties consumed can be written as an aggregate good $Q = U$ and the aggre-

gate price is given by

$$P = \left[\frac{1}{1 - G(\varphi^*)} \int_{\varphi^*}^{\infty} p(\varphi)^{1-\sigma} N g(\varphi) d\varphi \right]^{\frac{1}{1-\sigma}} . \quad (4)$$

Demand for each individual good will be given by

$$q(\varphi) = Q \left[\frac{p(\varphi)}{P} \right]^{-\sigma} \quad (5)$$

and revenue generated by one variety is

$$r(\varphi) = R \left[\frac{p(\varphi)}{P} \right]^{1-\sigma} \quad (6)$$

where $R = PQ$.

3.1.2 Production

Firms produce with constant marginal cost using only labor as an input. In order to set up the firm and enter the market, firms have to pay a sunk investment cost f_e . The effect of this will be discussed below for the free entry condition. In addition, firms pay a fixed overhead cost f every period. Fixed overhead costs for exporting are $f_x > f$. Productivity is given by φ and wages by w . Labor used can be written as $l = f + \frac{q}{\varphi}$. The investment cost play no role once the firm is in the market because it is a sunk cost. Investment cost f_e and overhead costs f and f_x are denoted in terms of labor. So the actual price that the firm has to pay is wf_e , wf and wf_x .

Domestic firms therefore optimally set a price of

$$p_d(\varphi) = \frac{w}{\rho\varphi} . \quad (7)$$

For each exported good, firms have to pay a transport cost τ which increases their marginal

cost. The price setting for export goods is thus

$$p_x(\varphi) = \frac{\tau w}{\rho \varphi}. \quad (8)$$

Inserting (7) into (6), we can express revenues as

$$r_d(\varphi) = R(P\rho\varphi)^{\sigma-1}. \quad (9)$$

Putting (8) into (6) yields the foreign revenues

$$r_x(\varphi) = R(P\rho\varphi)^{\sigma-1}\tau^{1-\sigma}. \quad (10)$$

Profits in the home and export market can thus be written as

$$\pi_d(\varphi) = r_d(\varphi) - l(\varphi) = \frac{r_d(\varphi)}{\sigma} - wf \quad (11)$$

$$\pi_x(\varphi) = r_x(\varphi) - l(\varphi) = \frac{r_x(\varphi)}{\sigma} - wf_x. \quad (12)$$

3.1.3 Revenue

From (9) that domestic revenue can be written as

$$r_d(\varphi) = \left(\frac{\varphi}{\varphi^*}\right)^{\sigma-1} r_d(\varphi^*). \quad (13)$$

Recall that φ^* is the marginal productivity at which a firm makes zero profits, $\pi_d(\varphi^*) = 0$.

Using (11), revenues are thus $r_d(\varphi^*) = \sigma wf$ so that we can write

$$r_d(\varphi) = \left(\frac{\varphi}{\varphi^*}\right)^{\sigma-1} \sigma wf. \quad (14)$$

Using (10), we can write

$$r_x(\varphi) = \tau^{1-\sigma} r_d(\varphi) = \tau^{1-\sigma} \left(\frac{\varphi}{\varphi^*}\right)^{\sigma-1} \sigma wf \quad (15)$$

and

$$\frac{r_x(\varphi_x^*)}{r_d(\varphi_x^*)} = \tau^{1-\sigma} \left(\frac{\varphi_x^*}{\varphi^*} \right)^{\sigma-1}, \quad (16)$$

where φ_x^* is the cut-off level for exports at which firms make zero profits from exporting.

As above for domestic revenues, we have $r_x(\varphi_x^*) = \sigma w f_x$ for export revenues so that

$$\frac{r_x(\varphi_x^*)}{r_d(\varphi_x^*)} = \frac{f_x}{f}. \quad (17)$$

3.1.4 Productivity

Joining (16) and (17), we obtain

$$\varphi_x^* = \varphi^* \tau f^*. \quad (18)$$

where $f^* = \left[\frac{f_x}{f} \right]^{\frac{1}{\sigma-1}}$.

The weighted average of productivity is given by (see appendix for details)

$$\begin{aligned} \tilde{\varphi}(\varphi^*) &= \left[\frac{1}{1 - G(\varphi^*)} \int_{\varphi^*}^{\infty} \varphi^{\sigma-1} g(\varphi) d\varphi \right]^{\frac{1}{\sigma-1}} \\ &= \left[\frac{\varphi^{*k}}{\varphi_m^k} \int_{\varphi^*}^{\infty} \varphi^{\sigma-1} k \frac{\varphi_m^k}{\varphi^{k+1}} d\varphi \right]^{\frac{1}{\sigma-1}} \end{aligned} \quad (19)$$

$$= k^* \varphi^*, \quad (20)$$

where $k^* = \left[\frac{k}{k - (\sigma-1)} \right]^{\frac{1}{\sigma-1}}$.

Average productivity of the exporting firms is given as

$$\tilde{\varphi}(\varphi_x^*) = k^* f^* \tau \varphi^*. \quad (21)$$

We define the share of exporters among domestic firms (which is also the probability of becoming an exporter for a new firm) as

$$p_x = \frac{1 - G(\varphi_x^*)}{1 - G(\varphi^*)}. \quad (22)$$

For the Pareto distribution, this is (see appendix for details).

$$p_x = \frac{1}{(\tau f^*)^k} . \quad (23)$$

Average total productivity is defined by

$$\tilde{\varphi}_{tot} = \left(\frac{1}{N_{tot}} [N \tilde{\varphi}^{\sigma-1} + N_x (\tau^{-1} \tilde{\varphi}_x)^{\sigma-1}] \right)^{\frac{1}{\sigma-1}} , \quad (24)$$

where $N_{tot} = N + N_x$ and $N_x = p_x N$.

In the case of the Pareto distribution, this simplifies to (see appendix for details)

$$\tilde{\varphi}_{tot} = k^* \varphi^* \left(\frac{\tau^k f^{*k} + f^{*\sigma-1}}{\tau^k f^{*k} + 1} \right)^{\frac{1}{\sigma-1}} . \quad (25)$$

3.2 Equilibrium

It remains to determine average profits, noted $\bar{\pi}$ and the cutoff productivity level φ^* . Average profits are obtained as the sum of the differences between revenues and costs from export and domestic production. The resulting equation is termed zero cutoff profit (ZCP) condition by [Melitz \(2003\)](#). Using this, cutoff productivity is then obtained from the free entry (FE) condition which says that the net value of entry must be zero.

Average profits $\bar{\pi}$ are defined as

$$\bar{\pi} = \pi_d(\tilde{\varphi}) + p_x \pi_x(\tilde{\varphi}_x) . \quad (26)$$

Using (13) for $\tilde{\varphi}$ yields an equation for revenues

$$r_d(\tilde{\varphi}) = \left(\frac{\tilde{\varphi}}{\varphi^*} \right)^{\sigma-1} r_d(\varphi^*)$$

which can be inserted into the profit function (11)

$$\pi_d(\tilde{\varphi}) = \left(\frac{\tilde{\varphi}}{\varphi^*}\right)^{\sigma-1} \frac{r_d(\varphi^*)}{\sigma} - wf. \quad (27)$$

Inserting $r_d(\varphi^*) = \sigma wf$ yields

$$\bar{\pi}_d = \pi_d(\tilde{\varphi}) = wf \left[\left(\frac{\tilde{\varphi}(\varphi^*)}{\varphi^*}\right)^{\sigma-1} - 1 \right]. \quad (28)$$

Export profits are derived analogously as

$$\bar{\pi}_x = \pi_x(\tilde{\varphi}) = wf_x \left[\left(\frac{\tilde{\varphi}(\varphi_x^*)}{\varphi_x^*}\right)^{\sigma-1} - 1 \right]. \quad (29)$$

Inserting (28) and (29) into (26), we get

$$\bar{\pi} = wf \cdot \left(\left[\frac{\tilde{\varphi}(\varphi^*)}{\varphi^*} \right]^{\sigma-1} - 1 \right) + p_x wf_x \cdot \left(\left[\frac{\tilde{\varphi}(\varphi_x^*)}{\varphi_x^*} \right]^{\sigma-1} - 1 \right)$$

This is the Zero Cutoff Profit condition. For the case of the Pareto distribution, it can be expressed as (see appendix for details)

$$\bar{\pi} = \left(wf + \frac{1}{\tau^k} wf^{\frac{-k}{\sigma-1}} f_x^{1-\frac{-k}{\sigma-1}} \right) \frac{\sigma-1}{k-(\sigma-1)}. \quad (30)$$

In order to keep notation clear, we have so far abstained from using a time index. This was possible since all calculations made so far used only variables of the same period. To calculate the net value of entry, however, we must sum over all expected future profits so that we have to introduce explicit time indices at this point. Average profits in period t can be expressed as

$$\bar{\pi}_t = (1 + \pi_{0,t}^w) w_0 \left(f + \frac{1}{\tau^k} f^{\frac{-k}{\sigma-1}} f_x^{1-\frac{-k}{\sigma-1}} \right) \frac{\sigma-1}{k-(\sigma-1)} \quad (31)$$

where $\pi_{0,t}^w$ denotes wage inflation between 0 and t .

Every period each firm faces a probability δ of a bad shock that forces it to exit. The value

of a firm is thus given as

$$\bar{v} = \sum_{t=0}^{\infty} (1 - \delta)^t \frac{1}{1 + \pi_{0,t}^w} \bar{\pi}_t . \quad (32)$$

Firms weight each period by the probability of still being in the market at this point in the future and adjust for inflation. But since $\bar{\pi}_t$ can be written in a way that allows the inflation term to be factored out, the inflation terms cancel and the firm value can be written in real terms as

$$\bar{v} = \frac{1}{\delta} \bar{\pi}_0 . \quad (33)$$

The probability of drawing a productivity above the cutoff is denoted with p_{in} . In order to enter the market, firms pay a one-off sunk investment cost of wf_e . The net value of entry is

$$v_e = p_{in} \bar{v} - w_0 f_e = \frac{1 - G(\varphi^*)}{\delta} \bar{\pi}_0 - w_0 f_e .$$

In equilibrium, there is free entry so that the net value of entry has to be zero. The free entry condition is thus

$$\begin{aligned} \bar{\pi}_0 &= \frac{\delta w_0 f_e}{1 - G(\varphi^*)} \\ &= \frac{\delta w f_e \varphi^{*k}}{(\varphi_m(t))^k} . \end{aligned} \quad (34)$$

Combining FE and ZCP yields

$$\varphi^* = \left[\frac{(\varphi_m(t))^k}{\delta f_e} \left(f + \frac{1}{\tau^k} f^{\frac{-k}{\sigma-1}} f_x^{1-\frac{-k}{\sigma-1}} \right) \frac{\sigma - 1}{k - (\sigma - 1)} \right]^{\frac{1}{k}} . \quad (35)$$

Substituting this value into the various expressions above allows to express the variables of the model depending on parameters. The equilibrium mass of domestic, exporting and total firms are given by

$$N = \frac{L}{\sigma(\bar{\pi} + f + p_x f_x)} \quad (36)$$

$$N_x = \frac{p_x L}{\sigma(\bar{\pi} + f + p_x f_x)} \quad (37)$$

$$N_{tot} = N + p_x N \quad (38)$$

where L aggregate labor.

3.3 The Price Level

Up to this point, the focus has been on the real side of the economy. As can be expected, all productivity variables do not depend on wages and prices. But in order to link this model to inflation, a monetary side needs to be introduced. For this, we simply impose a cash-in-advance constraint which allows us to analyze inflation in a straightforward way.

The budget constraint is given on a period-by-period basis. Consumers earn wages w and supply labor L inelastically. Revenue R is spent on consumption goods and can be written as the product of average prices $p(\tilde{\varphi})$, the average quantity supplied by each firm $q(\tilde{\varphi})$ and the mass N of active firms:

$$wL = p(\tilde{\varphi})q(\tilde{\varphi})N. \quad (39)$$

We impose a cash-in-advance constraint meaning that consumers have to hold money M equal to the total amount of purchases. And since purchases equal revenue, we can write

$$\begin{aligned} M &= R \\ &= p(\tilde{\varphi})q(\tilde{\varphi})N \\ &= w \frac{1}{\rho \tilde{\varphi}} q(\tilde{\varphi})N. \end{aligned} \quad (40)$$

3.4 Results

Lower transport cost eliminate the least productive domestic firms and increase the weight of high-productivity foreign firms in the domestic productivity index. A decrease in transport

cost leads to a new level of cost τ' with $\tau > \tau' > 1$.

Proposition 1 *Average productivity in a country increases as the transport cost decreases.*

$$\frac{\partial \tilde{\varphi}_{tot}}{\partial \tau} < 0. \quad (41)$$

For a given level of wages w average prices in the home country fall when transport costs fall:

$$\frac{\partial \tilde{p}}{\partial \tau} > 0.$$

Proof

In equation (25), average total productivity is given by

$$\tilde{\varphi}_{tot} = k^* \varphi^* \left(\frac{\tau^k f^{*k} + f^{*\sigma-1}}{\tau^k f^{*k} + 1} \right)^{\frac{1}{\sigma-1}}.$$

Denoting $F = \frac{\tau^k f^{*k} + f^{*\sigma-1}}{\tau^k f^{*k} + 1}$, the derivation can be written as

$$\frac{\partial \tilde{\varphi}_{tot}}{\partial \tau} = k^* \left[\frac{\partial \varphi^*}{\partial \tau} F^{\frac{1}{\sigma-1}} + \varphi^* \frac{1}{\sigma-1} F^{\frac{2-\sigma}{\sigma-1}} \frac{\partial F}{\partial \tau} \right]. \quad (42)$$

We now have to determine the sign of each of these terms:

$$\begin{aligned} \frac{\partial F}{\partial \tau} &= \frac{k\tau^{k-1}f^{*k}(\tau^k f^{*k} + 1) - (\tau^k f^{*k} + f^{*\sigma-1})k\tau^{k-1}f^{*k}}{(\tau^k f^{*k} + 1)^2} \\ &= \frac{k\tau^{k-1}f^{*k} - f^{*\sigma-1}k\tau^{k-1}f^{*k}}{(\tau^k f^{*k} + 1)^2} \\ &= \frac{k\tau^{k-1}f^{*k}(1 - f^{*\sigma-1})}{(\tau^k f^{*k} + 1)^2} \\ &= \frac{k\tau^{k-1}f^{*k}(1 - \frac{f_x}{f})}{(\tau^k f^{*k} + 1)^2} < 0 \end{aligned}$$

since $f < f_x \Leftrightarrow 1 < \frac{f_x}{f}$.

Taking derivatives from (35), we have $\frac{\partial \varphi^*}{\partial \tau} < 0$. This means that cutoff productivity increases when transport cost fall.

Substituting $\frac{\partial F}{\partial \tau} < 0$ and $\frac{\partial \varphi^*}{\partial \tau} < 0$ into (42) we have

$$\frac{\partial \tilde{\varphi}_t}{\partial \tau} < 0.$$

This completes the proof for the first statement. The second statement follows almost immediately. By the definition of $\tilde{\varphi}_{tot}$, the average price of firms is given by the price of the firm with average productivity

$$\tilde{p} = p(\tilde{\varphi}_{tot}).$$

Using the equation for prices (7) and proposition 1, we have

$$\frac{\partial p(\tilde{\varphi}_{tot})}{\partial \tau} = -\frac{w}{\rho \tilde{\varphi}_{tot}^2} \frac{\partial \tilde{\varphi}_{tot}}{\partial \tau} > 0.$$

□

In the next step, we show the theoretical link between transport cost and our measure of openness. Openness is defined as imports plus exports over GDP. But since countries are identical in this paper, imports are actually equal to exports. We define R_x as the total revenues from export and R_d as total revenues from domestic sales. Openness is then given as

$$Openness = \frac{Imports + Exports}{GDP} = \frac{2 \cdot Exports}{GDP} = \frac{2 \cdot R_x}{R_d + R_x}, \quad (43)$$

where

$$\begin{aligned} R_d &= \int_{\varphi^*}^{\infty} r_d(\varphi) N g(\varphi) d\varphi \\ R_x &= \int_{\varphi_x^*}^{\infty} r_x(\varphi) N_x g(\varphi) d\varphi. \end{aligned}$$

The integration limits are illustrated by the following list of production and export status:

Interval	Production Status	Total Revenue
$[\varphi_m, \varphi^*]$	no production	0
$[\varphi^*, \varphi_x^*]$	production for domestic market	$r_d(\varphi)$
$[\varphi_x^*, \infty]$	production for domestic market and export	$r_d(\varphi) + r_x(\varphi)$

Proposition 2 *Openness increases as the transport cost decrease:*

$$\frac{\partial \text{Openness}}{\partial \tau} < 0. \quad (44)$$

Proof Taking derivatives of domestic revenue (14) with respect to transport cost, we have

$$\frac{\partial r_d(\varphi)}{\partial \tau} = \varphi^{\sigma-1} \sigma \omega f(1-\sigma) \frac{\partial \varphi^*}{\partial \tau} > 0,$$

since $\frac{\partial \varphi^*}{\partial \tau} < 0$ and $\sigma > 1$.

The mass N of firms as given in equation (36). A decrease in transport cost τ increases the probability of exporting p_x as given in (23) which in turn reduces the equilibrium number of domestic firms N .

In addition, the lower bound of integration for R_d , given by φ^* , increases because of decreasing transport cost. In all, we can conclude

$$\frac{\partial R_d}{\partial \tau} > 0,$$

meaning that total revenue from domestic sales falls as a consequence of lower transport cost.

Taking derivatives of export revenue (15) with respect to transport cost, we have

$$\frac{\partial r_x(\varphi)}{\partial \tau} = \varphi^{\sigma-1} \sigma \omega f(1-\sigma) (\tau \varphi^*)^{-\sigma} \left(\frac{\partial(\tau \varphi^*)}{\partial \tau} \right) < 0.$$

To see this, note that using (35), we get

$$\tau \varphi^* = \left[\frac{\varphi_m^k}{\delta f_e} \left(\tau^k f + f^{\frac{-k}{\sigma-1}} f_x^{1-\frac{-k}{\sigma-1}} \right) \frac{\sigma-1}{k-(\sigma-1)} \right]^{\frac{1}{k}},$$

which depends positively on τ .

The effect of transport cost on the mass of exporters is given by the derivative of (37):

$$\frac{\partial N_x(\varphi)}{\partial \tau} = \frac{L\sigma\bar{\pi} + f}{(\sigma(\bar{\pi} + f + p_z + f_x))^2} \left(-\frac{k}{f^{*k}\tau^{k+1}} \right) < 0.$$

Taking derivatives of the export cut-off level (18) with respect to transport cost, we have

$$\frac{\partial \varphi_x^*}{\partial \tau} = f^* \left(\frac{\partial(\tau\varphi^*)}{\partial \tau} \right) > 0$$

meaning that the lower bound of integration for R_x falls when transport costs fall. In all, we have

$$\frac{\partial R_x}{\partial \tau} < 0.$$

Using the expression for openness from (43), this yields the result. \square

Combining propositions 1 and 2 shows the close connection between openness and productivity.

Proposition 3 *Every increase in openness implies ceteris paribus an increase in productivity.*

Proof As Proposition 2 illustrates, openness is strictly monotonically increasing in transport cost. Every level of openness is thus connected to a unique level of transport cost, the two variables are linked by a one-to-one relationship. Given proposition 1, every increase in openness means that productivity has to rise as well. \square

The results so far treated the effect of changes in transport cost on the economy. Next, we turn to the innovative process which increases productivity in a country over time even in the absence of globalization. The first observation is that the average productivity of firms *in the market* increases as the distribution of productivity *draws* moves to the right. This statement is non-trivial since the fraction of firms that is able to stay in the market is endogenously determined.

Proposition 4 *The average productivity of firms in the market increases over time*

$$\frac{\partial \tilde{\varphi}_{tot}}{\partial t} > 0. \quad (45)$$

Proof From equation (25), we can see that average productivity of firms in the market increases linearly in the cut-off level of productivity φ^* . The cut-off level itself depends linearly on the minimum level of productivity draws $\varphi_m(t)$, see equation (35). The minimum level of productivity was assumed to grow at a constant rate over time, equation (3). \square

In analogy to the case of transport cost, we can determine the effect of time via productivity on prices. Given assumption (3), quality-adjusted relative prices of goods become cheaper in terms of the wage over time.

Using equation (40), we can now summarize our results on the central role of productivity for inflation. The growth rate of a variable x is noted as g_x .

Proposition 5 *Inflation can be written as the difference in the growth rate of the money supply and total productivity*

$$\pi = g_M - g_{\tilde{\varphi}_{tot}} \quad (46)$$

whereas productivity depends on time as a result of innovation and on openness as a result of firm selection.

Proof From the budget constraint, we have $\frac{1}{\rho \tilde{\varphi}_{tot}} q(\tilde{\varphi}) N = L$ which is constant. Using (40), this allows to write

$$g_M = g_w. \quad (47)$$

Inflation can now be written in this way:

$$\begin{aligned} \pi &= g_p \\ &= g_w - g_{\tilde{\varphi}_{tot}} \\ &= g_M - g_{\tilde{\varphi}_{tot}} \end{aligned} \quad (48)$$

Given propositions 1 and 4, all increases in productivity resulting from innovation or firm selection as a consequence of lower transport cost (resp. higher openness) which are not actively offset by increases in the money supply decrease inflation. \square

If monetary policy is constant $M_t = M_0 \cdot e^{g_M t}$, then all changes in inflation will be driven by changes in average productivity. Furthermore, equation (46) shows why the model can explain the reduction in world-wide inflation *generally* without having to explain the disappearance of hyperinflation such as the one in Latin America in the early 1990s: The disappearance of hyperinflations is caused by better monetary policy reflected in the growth of money supply g_M .

However, it may be that monetary policy is not independent of productivity. If the central bank wanted to keep inflation constant for example it could make the money supply dependent on productivity $M(\tilde{\varphi})$ with $M'(\tilde{\varphi}) < 0$ such that $g_M = g_{\tilde{\varphi}}$. In this case, changes in productivity would be neutralized by monetary policy. For the historic development, this seems implausible since low levels of inflation are generally seen as desirable. It may however be the case for countries which already have low levels of inflation as central banks want to avoid deflation.

Proposition 5 gives a new perspective on the effect of openness on the monetary side of the economy. Following papers such as Romer (1993) and Rogoff (2003), the effect of openness on inflation has been investigated in the literature of Woodford (2007), Sbordone (2007) and others. In contrast to this literature, we take a new approach and include money in an otherwise standard Melitz model. This puts the focus on the long-term development and the role of productivity. It allows an appreciation of the effect on a global scale as we can use macro data which are available for a large range of countries.

4 Calibration of the Model

As a first empirical test of the model, we calibrate the deep parameters. The parameter values of $k = 2$, $\delta = 0.1$ and $f = 1$ are chosen as in Ghironi and Melitz (2005). The value of $\delta = 0.025$ for the quarterly data in Ghironi and Melitz (2005) is adjusted to 0.1 for the annual data used

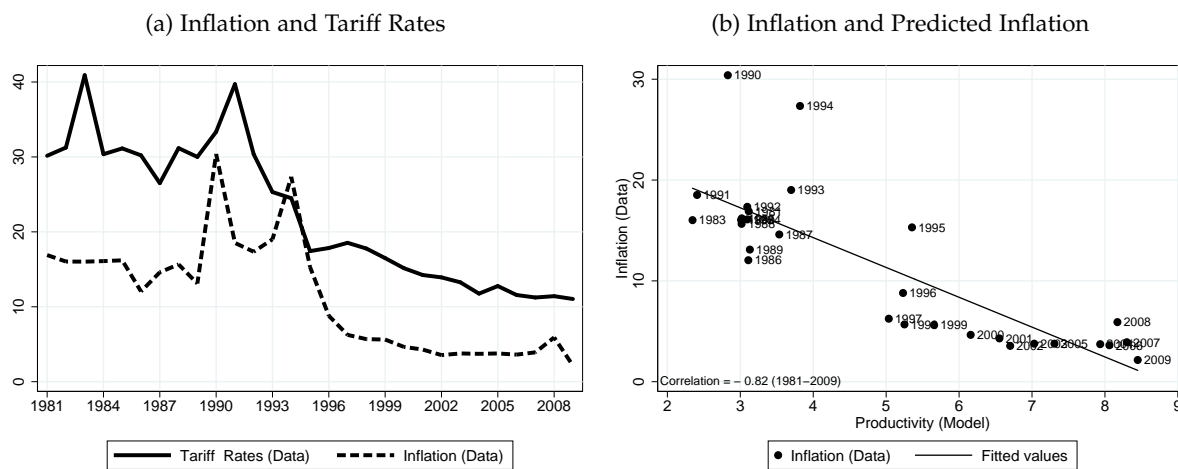
here. The parameter f_x is chosen to be 1.5 to reflect that for a local firm the fixed cost abroad are higher than the domestic fixed cost. As pointed out in [Philippon and Midrigan \(2011\)](#), the elasticity of substitution σ ranges from 0.5 to 4 in international macroeconomics. We follow their choice of an intermediate value by setting $\sigma = 1.4$. Using these parameter values and the data for transport cost from [World Bank \(2009\)](#), we can use equation (25) to obtain calibrated values for average productivity.

Figure 3a provides a descriptive comparison of tariff rates (bold line) with inflation (dashed line). Both of these variables show a similar development with a steady decline over the entire period and a particularly strong decline in the early 1990s. The time series for inflation features two marked spikes. The first one in 1990 reflects the hyperinflation in South America and the second one in 1994 that in Eastern Europe.

Figure 3b shows the correlation between calibrated values for productivity and data for inflation. Note that the values for productivity are not empirical data but show the productivity increase resulting from transport cost decreases as predicted in our model. We observe that this measure for productivity shows a steady increase. The strong correlation between increases in productivity and decreases in inflation is in line with the prediction of our model.

The model, however, abstracts from phenomena like the exchange rate regime which have a substantial influence on inflation. As a consequence, they are neglected in the calibration as well. Transport cost are not the only determinant of inflation. In order to control for these other influences, we need to conduct a full econometric analysis. For this, we make use of the testable prediction provided by Proposition 5. This econometric analysis is the subject of the next section.

Figure 3: Calibration of the Model



Notes: World Bank (2009) does not provide (average) world tariff rates data before 1986. We rely on the data aggregate of developing and low income countries (178 countries) to build an unweighted average of tariff rates. Tariff rates are used as a proxy for transport cost.
Sources: World Bank (2009), International Financial Statistics and authors' calculation.

5 Estimation of the Model

In section 2, we saw that inflation has fallen strongly as globalization deepened. This might of course be a coincidence only. Many explanations for falling inflation have been put forward, most prominently improved monetary policy. In this section, we will seek to establish a causal link controlling for monetary variables.

5.1 Description of the data

The data used for our regression analysis originates from various sources which we list here. The econometric results in table 3 to 9 start with the main regression followed by the inclusion of additional controls and robustness checks with alternative data sources. The presentation of the data follows this order. We use data for the period following the collapse of the Bretton Woods system in 1973 up to the most recent available data in 2009.

We compiled a data set of the variables described below for 175 countries. All countries that don not have at least 20 consecutive observations for inflation are deleted. This leaves a final sample of 123 countries with annual data for the period 1973-2009. The panel is balanced.

See table 10 for the list of countries included in the sample.

Productivity data are not available for all countries. We therefore approximate productivity growth with growth in GDP per capita. In studies involving a large number of countries, this approximation of productivity is a frequently used procedure (see for example Rodrik (2009) and Rogoff (1996)). The data for real GDP per capita is taken from the Penn World Table (6.2). To illustrate why this is a good approximation, see figure 4. The figure plots the growth rate of GDP per capita against that of productivity for all countries where data on productivity is available. Openness, also taken from the Penn World Table (6.2), is imports plus exports over GDP as in the theoretical part.

Our exchange rate regime classification is based on Levy-Yeyati and Sturzenegger (2003)¹. They use a *de facto* classification of exchange rate regimes based on cluster analysis techniques. Countries are sorted according to three variables: (i) Exchange rate volatility, (ii) Volatility of exchange rate changes, and (iii) Volatility of reserves. They are classified into three categories: 1 = float; 2 = intermediate and 3 = fixed.

Inflation targeting is a dummy variable with value zero when a country does not practice inflation targeting and one when it does. See Table 11 for the list of inflation targeting countries and the date they started the practice.

The remaining variables of table 3 are taken from the World Development Indicators (WDI) of the World Bank. The consumer price index, the dependent variable, is in the form of annual log differences. Money and quasi money is the total money supply. "It comprises the sum of currency outside banks, demand deposits other than those of the central government, and the time, savings, and foreign currency deposits of resident sectors other than the central government", according to the World Bank.

In the Political Rights Index of the NGO Freedom House, a country will receive the highest score if political rights are close to some ideals (free and fair elections, competitive parties, minorities have reasonable self government, etc.)². We transform this index via a logistic transformation to the interval between zero and one where one is the best possible score for

¹Due to the stability of the exchange rate regime for each country between 2000-2003, we extend the classification in this period to the period 2004-2009

²Freedom House, *Freedom in the World* <http://www.freedomhouse.org>, Last access, February 2013

quality of institutions. Since inflation tends to increase during war periods, we control also for war episodes. The data for war episodes is taken from [Fearon and Laitin \(2003\)](#)¹.

The exchange rate regime data is from [Reinhart and Rogoff \(2002\)](#). The dummy variable for institutional quality originates from the International Country Risk Guide.

5.2 Predictions derived from the theoretical model

Proposition 5 leads to a testable prediction: Inflation can be written as the difference of the growth rate of the money supply and the growth rate of productivity

$$\pi = g_M - g_{\tilde{\varphi}_{tot}} .$$

The growth rate of productivity in turn depends on time (Proposition 4) as it evolves as a result of ongoing innovative activity and on increases in openness (Proposition 3) which causes firm selection. In order to test our theoretical result, the most straightforward thing to do is therefore to estimate this equation. We implement it empirically as:

$$\begin{aligned} \Delta \ln \text{CPI}_{i,t} = & \beta_0 + \beta_1 \Delta \ln \text{Money-Supply}_{i,t} + \beta_2 \Delta \ln \text{Productivity}_{i,t} \\ & + \underbrace{\beta_3 \Delta \ln \text{Productivity}_{i,t} * \Delta \ln \text{Openness}_{i,t}}_{\text{openness-induced productivity}} \\ & + \beta_4 \Delta \ln \text{Openness}_{i,t} + \beta_5 \Delta \ln \text{CPI}_{i,t-1} + \beta' X_{i,t} + \mu_t + \gamma_i + \epsilon_{i,t} \end{aligned} \quad (49)$$

where $i = 1, \dots, 123$ indexes the countries and $t = 1, \dots, 37$ indexes the years (from 1973 to 2009). Δ indicates first differences. All variables are set in log differences except for the dummies. The dependent variable is the growth rate of the consumer price index. The first explanatory variable is the money supply (M2) followed by the two sources of productivity growth. Productivity is the log difference of GDP per capita and openness is the log difference of the ratio of import plus export over gross domestic product. Control variables are openness and the lagged value of inflation to capture persistence in inflation and potentially mean-reverting dynamics. Further controls are captured in $X_{i,t}$ including the exchange rate regime

¹Armed conflict, <http://new.prio.no>, Last access, February 2013

dummy (Levy-Yeyati and Sturzenegger (2003)) and inflation targeting dummy. μ_t and γ_i are the time and country-fixed effect and $\epsilon_{i,t}$ the error term.

This regression equation explicitly models the two types of productivity changes: changes that occur independently from trade are captured by β_2 and those occurring as a consequence of greater openness through the mechanism of the model are captured by β_3 . At the same time, it takes into account the two mechanisms through which globalization can affect inflation: the first one is the direct channel of openness captured by β_4 , the second is the indirect channel via productivity captured by β_3 . The derivative of inflation with respect to productivity can be expressed as

$$\frac{\partial \Delta \ln \text{CPI}}{\partial \Delta \ln \text{Productivity}} = \beta_2 + \beta_3 \cdot \Delta \ln \text{Openness}$$

with $\beta_2 < 0$ and $\beta_3 < 0$. A negative β_3 implies that openness causes an additional increase in productivity which slows down inflation. Given proposition 5, we also expect $\beta_1 > 0$.

5.3 Regression Methods

We estimate equation (49) with different regression techniques to address the various shortcomings of standard OLS. Table 3 is structured as follows. Odd column numbers include only the real variables. Each even column numbers uses the same regression technique as the preceding odd column, but adds monetary variables.

Columns (1) and (2) is simple OLS with country-fixed effects. Country-fixed effects allow to move beyond cross country comparison by investigating within-country variation over time. The OLS analysis is biased since we include lagged values of the dependent variable inflation among the regressors. We nevertheless report the regression results since the bias is inversely proportional to the time period of the panel (see Nickell (1981) and Hsiao (2003)). In our case we have 37 time periods so that the bias is expected to be small.

Columns (3) and (4) is OLS with country-fixed effect, robust standard errors and clustered countries. By clustering countries, we allow for intragroup correlation relaxing the previous hypothesis that the observations are independent across groups but not necessarily within groups.

When using OLS, there is a pitfall even when including country-fixed effects, robust standard errors and clustered countries: The endogeneity of productivity (and so openness). One possible source of this is reverse causality: less inflation leads to higher productivity because inflation volatility reduces along with the level thus reducing risk and increasing competition. The second cause of endogeneity is simultaneous causality: an omitted variable – like the quality of institutions – causes productivity to increase and inflation to decrease. To deal with this problem, we use the system of Generalized Method of Moments (GMM)¹, see columns (7) and (8). Following [Roodman \(2006\)](#), we do not include explicit fixed effect dummies in system GMM since it might cause bias. We do not cluster countries because GMM standard errors are robust. For comparison, we also show the results for difference GMM, see columns (5) and (6).

5.4 Estimation Results

In describing the estimation results, we follow the order of the tables. Table 3 is our baseline result and is presented in section 5.4.1. Additional control variables and robustness checks follow in section 5.4.2. There is no dataset which gives representative transport cost for each country on an annual basis. Data on tariff rates like [World Bank \(2009\)](#) for example is patchy and represents only part of total transport cost. We thus make use of the equivalence of transport cost and openness as given in Proposition 2 and use openness data instead of transport cost.

5.4.1 Main results

The sign of each variable is the same across all regression methods described above. Our discussion will thus be limited to column (8) which is the most sound econometric technique and includes all relevant variables².

¹These are Difference-GMM and System-GMM, see [Blundell and Bond \(2000\)](#) and [Roodman \(2006\)](#) for example. We focus here on the System-GMM since it reduces the biases associated with the Difference-GMM. For Difference-GMM, the lagged values of level variables are used as instruments while for the System-GMM, the lagged difference variables are used as instruments.

²In this paper, the importance of each variable in the explanation of the right hand side variable matters. This is why we report t-statistics instead of standard errors in each of the regression tables. To conserve space, we drop the negative sign in front of the value of the t-student when the coefficient is negative.

Starting with the control variables, we find that inflation inertia has a positive sign confirming the notion of the persistence of changes in inflation. In line with monetary theory, we find that growth in the money supply has a positive effect on inflation. The exchange rate regime is found to be insignificant in the benchmark regression. This control was included to take into account that a large number of countries use, officially or de facto, the euro or the dollar or have a fixed exchange rate to one of these currencies. The insignificance of this control variable suggests that the use of a common currency does not lead to common inflation levels. Inflation targeting seems to work as intended since it reduces inflation.

Now coming to the variables of interest to our theory, we find that an increase in openness reduces inflation. This confirms previously proposed theories for a link between openness and inflation such as the idea of a reduced incentive for surprise disinflations put forward by Rogoff (2003). An increase in productivity also lowers inflation, thus supporting the idea that a reduction in *relative* prices for goods does to some extent affect the price *level*. Finally, and crucially for our theory, the interaction term between openness and productivity also has a negative effect on inflation. This confirms the central concept of this paper that openness-induced productivity changes reduce the price level via lower relative prices for goods.

Alfaro (2005) documents the role of the exchange rate regime on inflation. Without controlling for productivity, she concludes that the exchange rate regime is more relevant than openness as an explanation of inflation. Our results however show that productivity provides the link between openness and inflation. Openness via productivity has a stronger impact on the level of inflation than the exchange rate regime. We find the effect of the exchange rate regime on inflation to be insignificant.

The results are likely to be a lower bound as we only have data for total inflation. De Gregorio et al. (1994) notes that inflation in tradeables is much lower than in non-tradeables. Since our effect of lower inflation through more international competition works mainly on tradeables, the strength of the effect is likely to be even stronger in this sector. It is an important contribution to explain where this difference in inflation rates originates.

5.4.2 Robustness Tests

It is possible that the correlation between changes in productivity and inflation is due to an omitted variable. An improvement in institutions or political leadership might cause both inflation to go down and trade to increase. The idea behind this is that leaders simultaneously stop using inflation taxation and start opening their countries in an attempt to improve economic performance. A sudden change of economic policy like this might be introduced by newly elected leaders. To check if this hypothesis is right we will run regression 3 and include a control for institutional quality in the set of control variables X_{it} .

It is difficult to measure the quality of institutions directly. But we may get a good idea of major changes in institutional quality from an index such as the “Freedom in the World” - index from Freedom House. This index measures the quality of political rights in a country and can be seen as an indicator of any sincere attempt to improve governance. So if the correlation between openness and inflation is indeed driven by institutional quality, the inclusion of any measure for institutional quality should dramatically reduce the significance of productivity and openness in the regressions. Including the index (see table 4), we find that this is not the case. We find that the “Freedom in the World”-index is only weakly significant and does not strongly change the effect of openness, productivity and its interaction.

A similar concern is the effect of wars. Wars might force a country to reduce international trade and drive up inflation. Controlling for this with the inclusion of a war dummy, we find that the dummy is not significant.

Table 5 addresses the concern that the results may be sensitive to the choice of periods. We split the sample period in two parts of roughly equal lengths. The split at 1989/1990 follows Kose et al. (2003). Some of the results are less strongly significant in the first period (1972 to 1989) which is likely due to a much slower pace of globalization during that period. Results in the second period (1990 to 2009) however are strongly significant and quite similar to those of the whole sample. Following this temporal split, table 6 shows the results for a geographical split by comparing OECD and non-OECD countries. Among several geographical robustness checks which we do not all report here, this one seems to be the most interesting since it

shows that the effect exists for high and low-income countries. Results hold in this analysis.

Table 7 is concerned with the possibility that the approximation of productivity growth with growth in per capita GDP is too rough to produce reliable results. The regression therefore includes only the 67 countries for which TFP data are available in [Kose et al. \(2009\)](#). Again, results are similar to the main regression. Tables 8 and 9 follow the same idea. The variables for exchange rate regimes and institutional quality are replaced alternative measures. In the case of exchange rate regimes, we use data from [Reinhart and Rogoff \(2002\)](#) and in the case of institutional quality from the International Country Risk Guide. As before, results are not strongly affected.

6 Conclusion and Policy Implications

This paper explores the central role of productivity as a link between openness to trade and inflation in a framework of heterogeneous firms. Theoretically, we adapt the model of [Melitz \(2003\)](#) to make explicit statements on the reaction of openness, productivity and relative prices to changes in transport cost. In addition, a CIA constraint permits to understand how the relative price changes translate into the price level and affect inflation.

Empirically, we make use of a purpose-made data set containing all the relevant variables for 123 countries from all regions of the world. Estimation of the central theoretical equation reveals a significant effect of openness-induced productivity increase on inflation. Using GMM and directly controlling for institutional quality, we give strong evidence that results are robust to omitted variable bias and reverse causality.

As a consequence of our result, the question arises how sustainable the low levels of inflation are. An increase in openness leads to an acceleration in productivity. This however is not a structural change to the economy, it lasts only as long as openness increases. Once openness stabilizes, theory predicts that inflation should rise to a higher level because productivity growth is no longer aided by firm selection from additional foreign competition. We can draw a policy implication from this. Once openness levels out, the additional downward pressure it had on inflation disappears. Central banks will have to adjust for this if they aim to keep

inflation at very low levels.

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7 Appendix

7.1 Simple Derivations

Average Productivity at Home

$$\begin{aligned}
 \tilde{\varphi}(\varphi^*) &= \left[\frac{\varphi^{*k}}{(\varphi_m(t))^k} \int_{\varphi^*}^{\infty} \varphi^{\sigma-1} k \frac{(\varphi_m(t))^k}{\varphi^{k+1}} d\varphi \right]^{\frac{1}{\sigma-1}} \\
 &= \left[\varphi^{*k} k \int_{\varphi^*}^{\infty} \frac{\varphi^{\sigma-1}}{\varphi^{k+1}} d\varphi \right]^{\frac{1}{\sigma-1}} \\
 &= \left[\varphi^{*k} k \int_{\varphi^*}^{\infty} \varphi^{\sigma-k-2} d\varphi \right]^{\frac{1}{\sigma-1}} \\
 &= \left[\varphi^{*k} k \left| \frac{1}{\sigma-k-1} \varphi^{\sigma-k-1} \right|_{\varphi^*}^{\infty} \right]^{\frac{1}{\sigma-1}} \\
 &= \left[\varphi^{*k} \frac{k}{k-(\sigma-1)} \varphi^{*\sigma-1-k} \right]^{\frac{1}{\sigma-1}} \\
 &= \left[\frac{k}{k-(\sigma-1)} \varphi^{*\sigma-1} \right]^{\frac{1}{\sigma-1}} \\
 &= \left[\frac{k}{k-(\sigma-1)} \right]^{\frac{1}{\sigma-1}} \varphi^*
 \end{aligned}$$

Note that $\left[\frac{k}{k-(\sigma-1)} \right]^{\frac{1}{\sigma-1}} > 0$.

$$\begin{aligned}
 \tilde{\varphi}(\varphi_x^*) &= \tilde{\varphi} \left(\tau \left(\frac{f_x}{f} \right)^{\frac{1}{\sigma-1}} \varphi^* \right) \\
 &= \left[\frac{k}{k-(\sigma-1)} \tau^{\sigma-1} \frac{f_x}{f} \varphi^{*\sigma-1} \right]^{\frac{1}{\sigma-1}} \\
 &= \left[\frac{k}{k-(\sigma-1)} \frac{f_x}{f} \right]^{\frac{1}{\sigma-1}} \tau \varphi^*
 \end{aligned}$$

Probability of Exporting

$$p_x = \frac{1 - G(\varphi_x^*)}{1 - G(\varphi^*)} = \frac{\left(\frac{(\varphi_m(t))}{\varphi_x^*}\right)^k}{\left(\frac{(\varphi_m(t))}{\varphi^*}\right)^k} = \frac{\varphi^{*k}}{\varphi_x^{*k}} = \frac{1}{(\tau f^*)^k}$$

Average total productivity Inserting the definitions of N_{tot} and N_x into the definition of average total productivity (24) we can write

$$\tilde{\varphi}_{tot} = \left(\frac{1}{1 + p_x} [\tilde{\varphi}^{\sigma-1} + p_x (\tau^{-1} \tilde{\varphi}_x)^{\sigma-1}] \right)^{\frac{1}{\sigma-1}}. \quad (50)$$

Substituting in the expressions from (20), (21) and (23) we obtain

$$\begin{aligned} \tilde{\varphi}_{tot} &= \left(\frac{1}{1 + (\tau f^*)^{-k}} [(k^* \varphi^*)^{\sigma-1} + (\tau f^*)^{-k} (k^* f^* \varphi^*)^{\sigma-1}] \right)^{\frac{1}{\sigma-1}} \\ &= k^* \varphi^* \left(\frac{\tau^k f^{*k} + f^{*\sigma-1}}{\tau^k f^{*k} + 1} \right)^{\frac{1}{\sigma-1}}. \end{aligned}$$

The zero cutoff profit function (ZCP)

$$\begin{aligned} \bar{\pi} &= f \cdot \left(\left[\frac{\tilde{\varphi}(\varphi^*)}{\varphi^*} \right]^{\sigma-1} - 1 \right) + p_x f_x \cdot \left(\left[\frac{\tilde{\varphi}(\varphi_x^*)}{\varphi_x^*} \right]^{\sigma-1} - 1 \right) \\ &= f \left[\frac{k^* \varphi^*}{\varphi^*} \right]^{\sigma-1} - f + \frac{1}{(\tau f^*)^k} f_x \left[\frac{k^* f^* \tau \varphi^*}{f^* \tau \varphi^*} \right]^{\sigma-1} - \frac{1}{(\tau f^*)^k} f_x \\ &= f \left[\frac{k}{k - (\sigma - 1)} \right] - f + \frac{1}{(\tau f^*)^k} f_x \left[\frac{k}{k - (\sigma - 1)} \right] - \frac{1}{(\tau f^*)^k} f_x \\ &= \left(f + \frac{1}{(\tau f^*)^k} f_x \right) \left[\frac{k}{k - (\sigma - 1)} \right] - \left(f + \frac{1}{(\tau f^*)^k} f_x \right) \\ &= \left(f + \frac{1}{(\tau f^*)^k} f_x \right) \left[\frac{k}{k - (\sigma - 1)} - 1 \right] \\ &= \left(f + \frac{1}{\tau^k} \left(\frac{f_x}{f} \right)^{\frac{k}{\sigma-1}} f_x \right) \left[\frac{\sigma - 1}{k - (\sigma - 1)} \right] \\ &= \left(f + \frac{1}{\tau^k} f^{\frac{-k}{\sigma-1}} f_x^{1 - \frac{-k}{\sigma-1}} \right) \frac{\sigma - 1}{k - (\sigma - 1)} \end{aligned}$$

7.2 Graphical Appendix

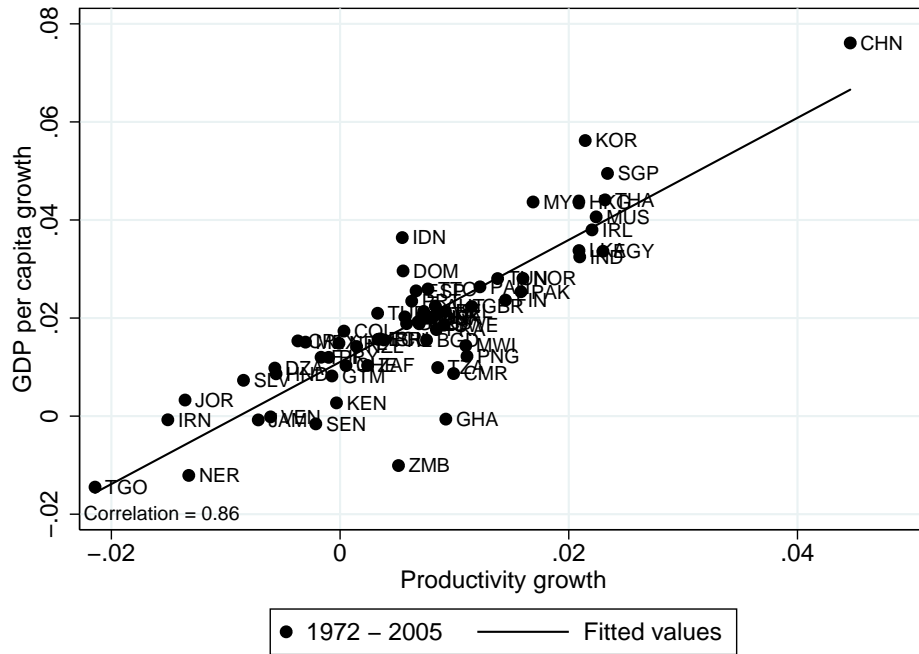


Figure 4: GDP per capita growth and productivity growth - 67 countries.

Sources: WDI, Kose et al. (2009) and authors' calculation.

7.3 Tables

	FE			GMM				
	OLS	OLS-Cluster	Diff GMM	System GMM				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Inflation inertia	0.6430*** [52.9460]	0.5625*** [39.3526]	0.6430*** [20.1036]	0.5625*** [18.9087]	0.6523*** [17.6712]	0.5253*** [12.5015]	0.6608*** [17.7495]	0.5336*** [12.8658]
$\Delta \ln$ Openness	-0.0492*** [6.5049]	-0.0472*** [5.8091]	-0.0492*** [3.6929]	-0.0472*** [3.5399]	-0.0474*** [3.6251]	-0.0362*** [2.7134]	-0.0464*** [3.5415]	-0.0362*** [2.7734]
$\Delta \ln$ Productivity	-0.1029*** [6.5853]	-0.1224*** [7.1297]	-0.1029*** [3.4636]	-0.1224*** [3.9534]	-0.1139*** [3.6862]	-0.1014*** [3.1726]	-0.1070*** [3.4678]	-0.1118*** [3.4080]
$\Delta \ln$ Productivity * $\Delta \ln$ Openness	-0.2976*** [4.2012]	-0.5016*** [6.0995]	-0.2976*** [2.6665]	-0.5016*** [3.8088]	-0.3247*** [3.0452]	-0.4357*** [3.1772]	-0.3088*** [2.7878]	-0.4365*** [3.3807]
$\Delta \ln$ Money supply		0.1040*** [14.4981]		0.1040*** [4.8848]		0.0826*** [3.6762]		0.0814*** [3.8442]
Exchange-rate regimes		-0.0056*** [3.4461]		-0.0056*** [2.4960]		-0.0034 [0.9000]		-0.0050 [1.4227]
Inflation targeting		-0.0178*** [3.1214]		-0.0178*** [2.5460]		-0.0654*** [2.9503]		-0.0108*** [2.3226]
Constant	0.0654*** [11.3280]	0.0841*** [10.7757]	0.0654*** [12.7182]	0.0841*** [8.5741]			0.0182*** [6.0392]	0.0250*** [2.4140]
Observations	3,960	3,106	3,960	3,106	3,833	2,868	3,960	3,106
Country Fixed Effects	Yes	Yes	Yes	Yes	No	No	No	No
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.5208	0.5670	0.5208	0.5670				
Number of countries	123	121	123	121	123	118	123	121

t-statistics in brackets, *** p<0.01, ** p<0.05, * p<0.1

Table 3: Main regression results

	FE			GMM				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Inflation inertia	0.6184*** [43.8728]	0.5436*** [32.9578]	0.6184*** [18.7303]	0.5436*** [17.5372]	0.6227*** [14.3297]	0.4846*** [10.2958]	0.6400*** [15.0228]	0.5403*** [13.0303]
$\Delta \ln$ Openness	-0.0524*** [6.0975]	-0.0491*** [5.3073]	-0.0524*** [3.6410]	-0.0491*** [3.3416]	-0.0460*** [3.2601]	-0.0337** [2.2749]	-0.0489*** [3.4626]	-0.0398*** [2.8183]
$\Delta \ln$ Productivity	-0.1005*** [5.5915]	-0.1182*** [6.0241]	-0.1005*** [3.0369]	-0.1182*** [3.5834]	-0.1122*** [3.2040]	-0.0953*** [2.7717]	-0.1033*** [2.9095]	-0.1086*** [2.9829]
$\Delta \ln$ Productivity * $\Delta \ln$ Openness	-0.2984*** [3.7570]	-0.5237*** [5.6893]	-0.2984** [2.5174]	-0.5237*** [3.8775]	-0.3291*** [2.8073]	-0.4481*** [3.0509]	-0.3277*** [2.7314]	-0.4715*** [3.2326]
$\Delta \ln$ Money supply	0.1074*** [12.9516]	0.1074*** [12.9516]	0.1074*** [12.9516]	0.1074*** [12.9516]	0.1074*** [12.9516]	0.0823*** [3.2064]	0.0823*** [3.2064]	0.0870*** [3.6772]
Exchange-rate regimes	-0.0070*** [3.4527]	-0.0070*** [3.4527]	-0.0070*** [3.4527]	-0.0070*** [3.4527]	-0.0070*** [3.4527]	-0.0040 [0.8140]	-0.0064 [0.8140]	-0.0064 [1.3365]
Inflation targeting	-0.0193** [2.2769]	-0.0193** [2.2769]	-0.0193** [2.2769]	-0.0193** [2.2769]	-0.0193** [2.2769]	-0.0666** [2.4573]	-0.0666** [2.4573]	-0.0231*** [3.1342]
Quality of institutions	0.0128** [2.0132]	0.0129* [1.7904]	0.0128** [2.1560]	0.0129* [1.7360]	0.0039 [0.1710]	-0.0102 [-0.4579]	0.0088 [0.5235]	0.0252* [1.8097]
<i>Freedom house index</i>	0.0154*** [2.9779]	0.0159*** [2.7165]	0.0154*** [2.3653]	0.0159*** [2.2221]	0.0013 [0.0716]	-0.0351 [-1.5029]	0.0128 [1.0465]	0.0071 [0.3994]
War dummy	0.0755*** [10.3725]	0.0812*** [8.2259]	0.0755*** [10.9706]	0.0812*** [6.5129]	0.0812*** [6.5129]	0.0812*** [6.5129]	0.0104 [0.9489]	0.0107 [0.6015]
Constant								
Observations	3,141	2,431	3,141	2,431	3,016	2,214	3,141	2,431
R-squared	0.4700	0.5284	0.4700	0.5284				
Country Fixed Effects	Yes	Yes	Yes	Yes	No	No	No	No
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of countries	121	118	121	118	121	115	121	118

t-statistics in brackets, *** p<0.01, ** p<0.05, * p<0.1

Table 4: Robustness Check: including institutional and conflict dummies as controls

	FE				GMM			
	OLS		OLS-Cluster		Diff GMM		System GMM	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	1973-1989	1990-2009	1973-1989	1990-2009	1973-1989	1990-2009	1973-1989	1990-2009
Inflation inertia	0.4678*** [18.3761]	0.5203*** [27.8058]	0.4678*** [10.3446]	0.5203*** [13.5300]	0.4429*** [5.6286]	0.4786*** [8.0827]	0.6406*** [12.8543]	0.4982*** [9.0285]
Δ In Openness	-0.0050 [0.3879]	-0.0795*** [7.7341]	0.0050 [0.2831]	-0.0795*** [5.3894]	-0.0103 [-0.4797]	-0.0643*** [3.6292]	-0.0027 [0.1319]	-0.0614*** [3.8390]
Δ In Productivity	-0.0998*** [3.8372]	-0.1400*** [5.9018]	-0.0998*** [2.7177]	-0.1400*** [2.8924]	-0.0773* [1.8535]	-0.1305*** [2.6781]	-0.1095** [2.3809]	-0.1281*** [2.7768]
Δ In Productivity * Δ In Openness	-0.3447* [2.1239]	-0.5276*** [5.6656]	-0.3447* [1.6743]	-0.5276*** [3.5474]	-0.3069 [1.3241]	-0.4305** [2.2748]	-0.4608* [1.7498]	-0.3741*** [2.6916]
Δ In Money supply	0.0778*** [6.6163]	0.1028*** [11.1253]	0.0778*** [3.0128]	0.1028*** [3.3508]	0.0409 [1.3103]	0.0861** [2.5250]	0.0856*** [3.3402]	0.0809*** [2.6424]
Exchange-rate regimes	-0.0068** [2.1456]	0.0001 [0.0317]	-0.0068* [1.7327]	0.0001 [0.0217]	0.0045 [0.7520]	-0.0062 [1.3462]	-0.0065 [1.2016]	-0.0075* [1.7138]
Inflation targeting		-0.0082 [1.1867]		-0.0082 [1.2168]		-0.0573*** [2.7940]		-0.0125** [2.3312]
Constant	0.0627*** [5.7269]	0.0143* [1.9577]	0.0627*** [4.5696]	0.0143 [1.2610]			0.0381** [2.5575]	0.0335** [2.6031]
Observations	1,308	1,798	1,308	1,798	1,167	1,701	1,308	1,798
R-squared	0.3459	0.5414	0.3459	0.5414				
Country Fixed Effects	Yes	Yes	Yes	Yes	No	No	No	No
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of countries	105	121	105	121	101	116	105	121

t-statistics in brackets; *** p<0.01, ** p<0.05, * p<0.1

The division into periods follows [Kose et al. \(2003\)](#). The second period coincides with the time of rapid globalization.

Table 5: Robustness Check: Sample split into time intervals

	FE				GMM							
	OLS		OLS-Cluster		Diff GMM		System GMM					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)				
	OECD	Non-OECD	OECD	Non-OECD	OECD	Non-OECD	OECD	Non-OECD	OECD	Non-OECD		
Inflation inertia	0.6351*** [27.0993]	0.5341*** [31.6248]	0.6351*** [14.6151]	0.5341*** [15.2939]	0.5925*** [10.8707]	0.4727*** [10.4613]	0.6037*** [16.3752]	0.5017*** [10.8791]				
$\Delta \ln$ Openness	-0.0917*** [3.6025]	-0.0446*** [4.9748]	-0.0917*** [2.0846]	-0.0446*** [3.1982]	-0.0963** [2.3517]	-0.0311** [2.3059]	-0.0846* [1.8650]	-0.0344** [2.5638]				
$\Delta \ln$ Productivity	-0.1484*** [2.8287]	-0.1098*** [5.7760]	-0.1484** [2.5774]	-0.1098*** [3.3521]	-0.1688** [2.7161]	-0.0855*** [2.6937]	-0.1678*** [3.0951]	-0.1020*** [2.9873]				
$\Delta \ln$ Productivity* $\Delta \ln$ Openness	-2.4745*** [4.8054]	-0.4802*** [5.3964]	-2.4745*** [1.6804]	-0.4802*** [3.5843]	-2.3355*** [1.5099]	-0.4039*** [3.0391]	-2.6468** [1.7494]	-0.4153*** [3.2741]				
$\Delta \ln$ Money supply	0.1183*** [10.9889]	0.0981*** [11.4150]	0.1183*** [4.2189]	0.0981*** [4.1581]	0.1299*** [4.2063]	0.0621*** [3.4656]	0.1331*** [4.5863]	0.0714*** [3.3747]				
Exchange-rate regimes	-0.0018 [0.7585]	-0.0045** [2.2201]	-0.0018 [0.6778]	-0.0045 [1.6072]	0.0029 [0.7377]	-0.0050 [1.0903]	-0.0008 [0.2158]	-0.0052 [1.3383]				
Inflation targeting	-0.0043 [0.8575]	-0.0247** [2.4431]	-0.0043 [0.8188]	-0.0247** [2.2578]	-0.0172* [2.0224]	-0.0423** [2.0058]	-0.0044 [1.3704]	-0.0035 [0.4616]				
Constant	0.0250** [2.3005]	0.0819*** [8.1840]	0.0250*** [3.2305]	0.0819*** [6.1585]			0.0066 [0.6312]	0.0284** [2.5204]				
Observations	672	2434	672	2434	623	2245	672	2434				
R-squared	0.8541	0.5004	0.8541	0.5004								
Country Fixed Effects	Yes	Yes	Yes	Yes	No	No	No	No				
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes				
Number of countries	26	95	26	95	26	92	26	95				

t-statistics in brackets; *** p<0.01, ** p<0.05, * p<0.1

Table 6: Robustness Check: Sample split into OECD vs Non-OECD countries

	GMM									
	FE			GMM						
	OLS			OLS-Cluster		Diff GMM		System GMM		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Inflation inertia	0.6621*** [40.4676]	0.5970*** [31.9771]	0.6621*** [13.2589]	0.5970*** [15.0265]	0.5771*** [14.4749]	0.6816*** [11.0967]	0.6075*** [9.4165]	0.6800*** [11.4973]	0.5870*** [9.3502]	0.5723*** [9.9459]
Δ ln Openness	-0.0755*** [6.7430]	-0.0695*** [5.8650]	-0.0755*** [3.7218]	-0.0695*** [2.9866]	-0.0715*** [2.8185]	-0.0729*** [3.5924]	-0.0737*** [3.0788]	-0.0713*** [3.5887]	-0.0666*** [2.9982]	-0.0649** [2.5965]
Δ ln Productivity	-0.1577*** [5.9528]	-0.1853*** [6.5251]	-0.1577*** [3.3879]	-0.1853*** [3.7102]	-0.1771*** [3.7452]	-0.1641*** [3.2604]	-0.1804*** [3.0509]	-0.1683*** [3.3589]	-0.1921*** [3.3982]	-0.1744*** [3.1760]
<i>Solow's residual</i>										
Δ ln Productivity * Δ ln Openness	-0.5142*** [3.0291]	-0.7071*** [4.0108]	-0.5142* [1.8108]	-0.7071** [2.3054]	-0.7667*** [2.6611]	-0.5511** [2.1125]	-0.5501** [2.1217]	-0.5465** [2.0609]	-0.6202** [2.3500]	-0.7439*** [2.8707]
Δ ln Money supply		0.0973*** [10.5221]		0.0973*** [3.8703]	0.0982*** [3.8683]		0.0904*** [3.9790]		0.0876*** [3.4661]	0.0960*** [4.2282]
Exchange-rate regimes		-0.0042** [2.2343]		-0.0042* [1.6880]	-0.0047* [1.7189]		0.0025 [0.5523]		0.0013 [0.2960]	0.0021 [0.4303]
Inflation targeting		-0.0105* [1.7046]		-0.0105 [1.4071]	-0.0165* [1.6942]		-0.0028 [0.1043]		-0.0108** [2.1282]	-0.0183** [2.3823]
Quality of institutions					0.0197** [2.0644]					0.0208 [0.9770]
<i>Freedom house index</i>					0.0185** [2.4978]					0.0207 [1.2016]
War dummy										-0.0123 [0.5135]
Constant	0.0369*** [5.5096]	0.0250*** [3.0515]	0.0369*** [3.1166]	0.0250*** [2.9639]	0.0164 [1.1493]			0.0161*** [3.4385]	0.0094 [0.8168]	
Observations	2,136	1,743	2,136	1,743	1,487	2,069	1,609	2,136	1,743	1,487
R-squared	0.5592	0.5999	0.5592	0.5999	0.5658					
Country Fixed Effects	Yes	Yes	Yes	Yes	No	No	No	No	No	No
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of countries	67	66	67	66	65	67	66	67	66	65

t-statistics in brackets, *** p<0.01, ** p<0.05, * p<0.1

Table 7: Robustness Check: With productivity data from Kose et al. (2009)

	FE			GMM						
	OLS	OLS-Cluster	Diff GMM	Diff GMM			System GMM			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Inflation inertia	0.6313*** [49.6312]	0.5114*** [30.0054]	0.6313*** [19.3218]	0.5114*** [13.3610]	0.4996*** [13.5807]	0.6435*** [17.0186]	0.5004*** [9.9319]	0.6504*** [17.0292]	0.4930*** [10.6883]	0.4903*** [10.9030]
Δ ln Openness	-0.0502*** [6.4180]	-0.0480*** [4.5325]	-0.0502*** [3.6864]	-0.0480*** [2.7302]	-0.0445*** [2.4502]	-0.0480*** [3.5601]	-0.0483*** [2.7192]	-0.0470*** [3.4638]	-0.0475*** [2.8201]	-0.0426** [2.5327]
Δ ln Productivity	-0.1061*** [6.5350]	-0.1545*** [6.1973]	-0.1061*** [3.5000]	-0.1545*** [4.2924]	-0.1462*** [4.1381]	-0.1180*** [3.7627]	-0.1502*** [3.2788]	-0.1130*** [3.5575]	-0.1532*** [3.6312]	-0.1373*** [3.4677]
Δ ln Productivity * Δ ln Openness	-0.2937*** [4.0308]	-0.5345*** [3.8761]	-0.2937*** [2.6169]	-0.5345*** [2.7238]	-0.7190*** [3.6362]	-0.3329*** [3.1164]	-0.5101** [2.5876]	-0.3237*** [2.9389]	-0.5629*** [2.8408]	-0.6624*** [3.3876]
Δ ln Money supply	0.0910*** [10.6189]	0.0910*** [10.6189]	0.0910*** [2.6169]	0.0910*** [4.5419]	0.0904*** [4.5084]	0.0904*** [4.5084]	0.0758*** [4.3698]	0.0758*** [4.1241]	0.0767*** [4.1241]	0.0806*** [5.0148]
Exchange rate regimes	0.0221*** [16.1316]	0.0221*** [16.1316]	0.0221*** [7.4686]	0.0221*** [7.4686]	0.0225*** [7.0083]	0.0221*** [7.0083]	0.0241*** [5.9621]	0.0230*** [6.3679]	0.0255*** [6.3679]	0.0255*** [6.8637]
ERR of <i>Reinhart and Rogoff (2002)</i>	-0.0303*** [5.3667]	-0.0303*** [5.3667]	-0.0303*** [4.1244]	-0.0303*** [4.1244]	-0.0344*** [4.0172]	-0.0344*** [4.0172]	-0.0831** [2.4990]	-0.0381*** [5.9553]	-0.0509*** [6.0430]	-0.0509*** [6.0430]
Quality of institutions	0.0079 [0.8001]	0.0079 [0.8001]	0.0079 [0.8001]	0.0079 [0.8001]	0.0079 [0.8001]	0.0079 [0.8001]	0.0079 [0.8001]	0.0079 [0.8001]	0.0079 [0.8001]	0.0079 [0.8001]
<i>Freedom house index</i>	0.0124* [1.9572]	0.0124* [1.9572]	0.0124* [1.9572]	0.0124* [1.9572]	0.0124* [1.9572]	0.0124* [1.9572]	0.0124* [1.9572]	0.0124* [1.9572]	0.0124* [1.9572]	0.0124* [1.9572]
War dummy	0.0860*** [14.3529]	0.0351*** [5.1112]	0.0860*** [14.2070]	0.0351*** [3.3231]	0.0090 [0.8207]	0.0090 [0.8207]	0.0090 [0.8207]	0.0235*** [6.7293]	-0.0229*** [2.8204]	-0.0442*** [3.5409]
Constant	0.0860*** [14.3529]	0.0351*** [5.1112]	0.0860*** [14.2070]	0.0351*** [3.3231]	0.0090 [0.8207]	0.0090 [0.8207]	0.0090 [0.8207]	0.0235*** [6.7293]	-0.0229*** [2.8204]	-0.0442*** [3.5409]
Observations	3,715	2,000	3,715	2,000	1,736	3,588	1,919	3,715	2,000	1,736
R-squared	0.5021	0.6353	0.5021	0.6353	0.6038	0.6038	0.6038	0.6038	0.6038	0.6038
Country Fixed Effects	Yes	Yes	Yes	Yes	No	No	No	No	No	No
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of countries	123	67	123	67	65	123	67	123	67	65
t-statistics in brackets, *** p<0.01, ** p<0.05, * p<0.1										

Table 8: Robustness check: Exchange-Rate Regime classification following [Reinhart and Rogoff \(2002\)](#)

	FE			GMM										
	OLS	OLS-Cluster	Diff GMM	System GMM	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Inflation inertia	0.6313*** [49.6312]	0.5520*** [36.9592]	0.6313*** [19.3218]	0.5520*** [18.1574]	0.5923*** [14.4649]	0.6435*** [17.0186]	0.5196*** [12.0114]	0.6504*** [17.0292]	0.5295*** [12.7047]	0.5997*** [8.9523]				
Δ ln Openness	-0.0502*** [6.4180]	-0.0473*** [5.6105]	-0.0502*** [3.6864]	-0.0473*** [3.4271]	-0.0696*** [2.7126]	-0.0480*** [3.5601]	-0.0379*** [2.6640]	-0.0470*** [3.4638]	-0.0372*** [2.6709]	-0.0640*** [2.5448]				
Δ ln Productivity	-0.1061*** [6.5350]	-0.1272*** [7.1229]	-0.1061*** [3.5000]	-0.1272*** [4.0475]	-0.1916*** [3.7293]	-0.1180*** [3.7627]	-0.1028*** [3.1923]	-0.1130*** [3.5575]	-0.1188*** [3.5883]	-0.1092*** [3.3625]				
Δ ln Productivity * Δ ln Openness	-0.2937*** [4.0308]	-0.5028*** [5.9382]	-0.2937*** [2.6169]	-0.5028*** [3.7920]	-0.7557*** [3.1244]	-0.3329*** [3.1164]	-0.4086*** [3.0027]	-0.3237*** [2.9389]	-0.4251*** [3.2406]	-0.8356*** [3.8474]				
Δ ln Money supply		0.1066*** [14.2563]		0.1066*** [4.8134]	0.0972*** [3.9060]		0.0826*** [3.5950]		0.0823*** [3.7904]					
Exchange-rate regimes		-0.0061*** [3.4055]		-0.0061*** [2.3799]	-0.0051** [2.0364]		-0.0010 [0.2255]		-0.0052 [1.2417]					
Inflation targeting		-0.0175*** [2.7782]		-0.0175*** [2.3424]	-0.0134* [1.8533]		-0.1071*** [3.0454]		-0.0134*** [2.6975]					
Quality of Institutions					-0.0021*									
ICRG Index					[1.9169]									
War dummy					0.0118*									
Constant	0.0860*** [14.3529]	0.0859*** [10.5105]	0.0860*** [14.2070]	0.0859*** [8.2353]	0.0495*** [3.3072]			0.0235*** [6.7293]	0.0338*** [2.8380]	0.0385** [2.1459]				
Observations	3,715	2,898	3,715	2,898	1,664	3,588	2,671	3,715	2,898	1,664				
R-squared	0.5021	0.5513	0.5021	0.5513	0.6088									
Country Fixed Effects	Yes	Yes	Yes	Yes	No	No	No	No	No	No				
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes				
Number of countries	123	119	123	119	62	123	118	123	119	62				

t-statistics in brackets, *** p<0.01, ** p<0.05, * p<0.1

Table 9: Robustness check: Institutional Quality Data from the International Country Risk Guide (ICRG)

Algeria, Australia, Austria, The Bahamas, Bahrain, Bangladesh, Barbados, Belgium, Belize, Bhutan, Botswana, Brunei Darussalam, Burkina Faso, Burundi, Cameroon, Canada, Cape Verde, Central African Republic, Chad, China, Colombia, Rep. Congo, Costa Rica, Cote d'Ivoire, Cyprus, Denmark, Dominica, Dominican Republic, Ecuador, Arab Rep. Egypt, El Salvador, Equatorial Guinea, Ethiopia, Fiji, Finland, France, Gabon, The Gambia, Ghana, Greece, Grenada, Guatemala, Guinea-Bissau, Haiti, Honduras, Hong Kong SAR, Hungary, Iceland, India, Indonesia, Islamic Rep. Iran, Ireland, Israel, Italy, Jamaica, Japan, Jordan, Kenya, Rep. Korea, Kuwait, Lao PDR, Lesotho, Libya, Luxembourg, Madagascar, Malawi, Malaysia, Mali, Malta, Mauritania, Mauritius, Mexico, Morocco, Myanmar, Nepal, Netherlands, Netherlands Antilles, New Zealand, Niger, Nigeria, Norway, Pakistan, Panama, Papua New Guinea, Paraguay, Philippines, Poland, Portugal, Qatar, Romania, Rwanda, Samoa, Saudi Arabia, Senegal, Seychelles, Singapore, Solomon Islands, South Africa, Spain, Sri Lanka, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Sudan, Suriname, Swaziland, Sweden, Switzerland, Syrian Arab Republic, Tanzania, Thailand, Togo, Tonga, Trinidad and Tobago, Tunisia, Turkey, Uganda, United Kingdom, United States, Uruguay, Vanuatu, RB Venezuela, Rep. Yemen, Zambia,

Table 10: List of Countries – Full Sample

Australia (1993), Canada (1991), Colombia (1999), Ghana (2007), Hungary (2001), Iceland (2001), Israel (1992), Rep. Korea (1998), Mexico (1999), New Zealand (1990), Norway (2001), Philippines (2002), Poland (1998), Romania (2005), South Africa (2000), Sweden (1993), Switzerland (2000), Thailand (2000), Turkey (2006), United Kingdom (1992).

The year in brackets refers to the year when inflation targeting was adopted.

Table 11: List of Inflation Targeting Countries