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THE EFFECT OF CAPITAL-FLOWS COMPOSITION ON OUTPUT VOLATILITY

PABLO FEDERICO, CARLOS VEGH Y GUILLERMO VULETIN

ABSTRACT

By distinguishing between foreign direct investment (FDI) and portfolio and other investments (OTR), we study the effects of the composition of capital inflows on output volatility. We develop a simple empirical model which, under certain conditions satisfied in the data, yields three key testable implications. First, output volatility should depend positively on FDI and OTR volatility. Second, output volatility should be an increasing function of the correlation between FDI and OTR. Third, for low values of the FDI share, output volatility should be a decreasing function of the share of FDI in total capital inflows. We find strong support in the data for all three implications, even after controlling for other factors that may influence output volatility and dealing with potential endogeneity problems.

JEL classification: F23; F32; F36; F44
Keywords: Foreign direct investment; capital inflows; output volatility.

RESUMEN

Al distinguir entre inversión extranjera directa (FDI) e inversión de portafolio y otras inversiones (OTR), estudiamos los efectos de la composición de flujos de capital en la volatilidad del producto. Para eso, desarrollamos un modelo empírico simple donde, bajo ciertas condiciones satisfechas por los datos, pueden evaluarse tres implicancias clave. Primero, la volatilidad del producto debería depender positivamente en la volatilidad FDI y OTR. Segundo, la volatilidad del producto debería ser una función creciente de la correlación entre FDI y OTR. Tercero, para valores bajos de la participación de FDI, la volatilidad del producto debería ser una función decreciente de FDI en los flujos totales de capital. Encontramos evidencia fuerte en los datos a favor de las tres implicancias, incluso luego de controlar por otros factores que pueden tener influencia sobre la volatilidad del producto y de lidiar con potenciales problemas de endogeneidad.

Clasificación JEL: F23; F32; F36; F44
Palabras clave: Inversión extranjera directa; flujos de capital; volatilidad del producto.

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THE EFFECT OF CAPITAL-FLOWS COMPOSITION ON OUTPUT VOLATILITY[1]

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I. Introduction

There is by now a large literature that has focused on the effects of foreign direct investment (FDI) on growth. The overall consensus appears to be that, provided that the right economic environment is in place, FDI will indeed stimulate growth.[5] Much less attention, if at all, has been paid to the link between capital inflows volatility and output volatility.[6] In particular, there has been little formal analysis of the idea – often found in policy circles – that FDI should be encouraged because it should lead to lower output volatility. As the logic goes, FDI is more stable than other sources of capital inflows, most notably portfolio and other investments (OTR), and therefore should be encouraged in order to ensure a less volatile level of domestic output.

This paper tackles head on the question of whether more FDI leads to a less volatile level of output.[7] To organize the discussion and provide a guide to the empirical analysis, we first develop a simple empirical model of the relationship between output and capital inflows. The model draws on standard portfolio

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[2] BlackRock.
[3] World Bank.
[4] World Bank.

[5] See, among others, Alfaro *et al* (2007, 2010), Borenzstein *et al* (1998), and Carkovic and Levine (2005).

[6] A related question – the potential beneficial effects of FDI in reducing the frequency of crises and/or sudden stops – has been addressed in Fernandez-Arias and Hausmann (2001) and Levchencko and Mauro (2007). For an early, skeptical look at the notion that long-term flows may be stabilizing, see Claessens, Dooley, and Warner (1995). Using firm level data, Alfaro and Chenz (2012) analyze the role of FDI on establishment performance before and after the global financial crisis of 2008.

[7] At a firm level and for European countries, Kalemli-Ozcan, Sørensen, and Volosovych (2010) find a positive effect of foreign ownership on volatility of firms' outcomes.

theory in which the volatility of an investor's portfolio depends on the volatilities of the underlying investments. We show that output volatility depends not only on the volatility of FDI and OTR but also on the correlation between FDI and OTR and the share of FDI in total capital inflows.

The model calls attention to some important caveats that need to be taken into account for some commonly-held beliefs to be true. For example, if would seem intuitively obvious that lower FDI volatility should lead to lower output volatility. This is not, however, necessarily the case. In fact, if the correlation between FDI and OTR is negative, then lower FDI volatility will *increase* output volatility because FDI cannot provide as much insurance against the volatility of OTR. By the same token, another "obvious" idea – that a higher share of FDI should lead to lower output volatility – is only true in the model if the actual share of FDI in total capital inflows is below the share of FDI that minimizes overall output variability.

We use the model to derive three key testable implications:

- If the correlation between FDI and OTR is zero or positive, output volatility should also depend positively on FDI volatility and OTR volatility.
- Output volatility should be an increasing function of the correlation between FDI and OTR.
- Output volatility should be a decreasing function of the share of FDI in total capital inflows, particularly when its initial value is low.

We test the model's predictions using a sample of 59 countries for the period 1970-2009.[8] For this purpose, we construct five-year non-overlapping series of volatilities and other portfolio and macroeconomic variables. Our empirical findings strongly support our model's implications.

We control for other possible determinants of output volatility, such as government spending volatility, terms of trade volatility, and country instability. We address endogeneity concerns by using three sets of instruments: (i) five-year non-overlapping lags of portfolio variables, (ii) gravity-based portfolio variables

[8] The number of countries was dictated by data availability on foreign direct investment and other capital flows.

aiming at capturing regional/location effects, and (iii) five-year non-overlapping lags of *de jure* and *de facto* measures of restrictions on cross-border financial transactions. Our main findings continue to hold even after controlling for other factors and using instrumental variables.

The paper proceeds as follows. Section 2 develops our simple empirical model. Section 3 discusses the data. Section 4 presents the econometric estimates. Section 5 concludes. An appendix develops a theoretical model that formalizes the tight link between capital inflows and output.

II. Empirical model

To organize ideas and guide our empirics, this section develops a simple empirical model of the relation between output volatility and capital inflows volatility. Consider a small open economy with the following technology:

$$Y = AK, \tag{1}$$

where Y is output, A is a positive technological parameter, and K is a (tradable) capital good. Let p be the international price of this capital good.[9]

The capital stock consists of this period's addition to the existing capital stock:

$$K = K_{-1} + \Delta K.$$

Assume that the purchase of this period's capital good must be fully financed by capital inflows, either in the form of foreign direct investment (FDI) or portfolio and other investments (OTR).[10] Formally,

$$\Delta K = \frac{FDI + OTR}{p}.$$

Solving for p and substituting in (1), we obtain

$$Y = \tilde{A}K_{-1} + \tilde{A}TF, \tag{2}$$

[9] This price could also be interpreted as a rental price. For the purposes of our analysis, we will assume that this price does not change over time.

[10] We are abstracting, of course, from domestic savings as a source of financing in order to focus exclusively on the effects of volatility of foreign financing on domestic output.

where

$$TF \equiv FDI + OTR, \tag{3}$$

denotes total capital inflows and $\tilde{A} \equiv A/p$. Output is thus a linear function of total capital inflows.[11]

Let $\overline{Y}$ and $\overline{TF}$ denote the means of output and total capital flows, respectively. It then follows from (2) that

$$\sigma_Y^2 = \tilde{A}^2 \sigma_{TF}^2. \tag{4}$$

Output volatility is thus an increasing function of capital inflows volatility. To proceed further, we need to impose more structure. Specifically, let us assume that the stochastic processes for FDI and OTR take the following multiplicative form:

$$FDI = \overline{FDI}\left(1 + \varepsilon_{FDI}\right), \tag{5}$$

$$OTR = \overline{OTR}\left(1 + \varepsilon_{OTR}\right), \tag{6}$$

where $\overline{FDI}$ and $\overline{OTR}$ are the means of FDI and OTR, respectively, $\varepsilon_{FDI} \sim N\left(0, \sigma_{FDI}^2\right)$, $\varepsilon_{OTR} \sim N\left(0, \sigma_{OTR}^2\right)$, and ε_{FDI} and ε_{OTR} are jointly normally distributed. For further reference, let ρ denote the correlation between ε_{FDI} and ε_{OTR}.[12]

Let ϕ denote the share of FDI in total capital inflows; that is,

$$\overline{FDI} = \phi\overline{TF}, \tag{7}$$

$$\overline{OTR} = (1 - \phi)\,\overline{TF}, \tag{8}$$

where $\overline{TF}$ is the mean of TF.Since TF is the sum of FDI and OTR, it will inherit the multiplicative stochastic structure of FDI and OTR. To see this,

[11] This very tight link between output and capital flows is the key assumption behind our empirical model. (While helpful to organize the empirical work, what folows below is, formally, a mechanical elaboration of this main idea in a stochastic setting and involves no implicit theorizing.) To provide some theoretical basis for this assumption, the appendix develops a simple theoretical framework with heterogenous firms which delivers an equilibrium relationship between FDI and OTR, on the one hand, and output on the other. In this context, the appendix shows how fluctuations in, for instance, the cost of long-term financing leads to fluctuations in output, FDI and OTR.

[12] The normality assumption is not essential for our results to go through.

substitute (5) and (6) into (3), and use (7) and (8), to obtain

$$TF = \overline{TF}[\phi\,(1+\varepsilon_{FDI}) + (1-\phi)\,(1+\varepsilon_{OTR})].$$

Hence,

$$\sigma^2_{TF} = \overline{TF}^2\left[\phi^2\sigma^2_{FDI} + (1-\phi)^2\,\sigma^2_{OTR} + 2\phi\,(1-\phi)\,\sigma_{FDI}\sigma_{OTR}\rho\right]. \quad (9)$$

From (2), $\sigma^2_Y = \tilde{A}^2\sigma^2_{TF}$. Using (9), we can express output volatility as

$$\sigma^2_Y = \left(\tilde{A}\overline{TF}\right)^2\left[\phi^2\sigma^2_{FDI} + (1-\phi)^2\,\sigma^2_{OTR} + 2\phi\,(1-\phi)\,\sigma_{FDI}\sigma_{OTR}\rho\right]. \quad (10)$$

This equation thus relates output volatility (σ^2_Y) to the volatility of foreign direct investment (σ^2_{FDI}), the volatility of portfolio and other investments (σ^2_{OTR}), the correlation between FDI and OTR (ρ), and the share of FDI in total capital inflows (ϕ).

Even though the model is extremely simple, expression (10) already warns us that some commonly-held beliefs regarding the beneficial role of FDI in bringing about lower output volatility in emerging markets are in fact not obvious on closer examination. In particular, we can see that while equation (4) indicates that lower capital inflows volatility does imply lower output volatility, equation (10) tells us that whether lower FDI volatility will actually translate into lower output volatility depends on the correlation between FDI and OTR. As will become clear below, if $\rho < 0$, lower FDI volatility could actually lead to higher output volatility! Also, the effect of ϕ on output volatility is, in principle, ambiguous. In fact, it is possible that a larger share of FDI will lead to higher, rather than lower, output volatility. This suggests that we need to be careful in establishing the conditions under which these ideas may be true and then check in the data if these conditions hold.

To gain insights into expression (10), let us proceed by considering some special cases.

- Case 1: Variances of FDI and OTR are the same and the correlation is one (i.e., $\sigma^2_{FDI} = \sigma^2_{OTR}$ and $\rho = 1$). Expression (10) then reduces to

$$\sigma^2_Y = \left(\tilde{A}\overline{TF}\right)^2\sigma^2_{FDI}.$$

Output volatility does not depend on ϕ. Since the variances of FDI and OTR are the same and the correlation is one, there is essentially no difference between FDI and OTR and hence the share of FDI is irrelevant. In this case, higher FDI (or OTR) volatility translates into higher output volatility.

- Case 2: Variances of FDI and OTR are the same, $\phi = 0.5$, and there is a perfect negative correlation (i.e., $\sigma^2_{FDI} = \sigma^2_{OTR}$ and $\rho = -1$). In this case, $\sigma^2_Y = 0$. This can be thought of as the "full insurance" case. Due to the perfectly negative correlation, equal variances, and equal share, total capital inflows are constant and hence output volatility is zero.

- Case 3. Variances of FDI and OTR are the same and the correlation is zero (i.e., $\sigma^2_{FDI} = \sigma^2_{OTR}$ and $\rho = 0$). In this case, expression (10) reduces to

$$\sigma^2_Y = \left(\tilde{A}\overline{TF}\right)^2 \sigma^2_{FDI}\left[\phi^2 + (1-\phi)^2\right]. \tag{11}$$

This is the typical benchmark in basic portfolio theory. Think of an investor with two uncertain sources of income (FDI and OTR) that have the same variance but are uncorrelated. What is the share of FDI that would minimize the volatility of the overall portfolio? Set $\sigma^2_{FDI} = \sigma^2_{OTR}$ and $\rho = 0$ in (10) and differentiate with respect to ϕ to obtain,

$$\frac{d\sigma^2_Y}{d\phi} = 2\left(\tilde{A}\overline{TF}\right)^2 \sigma^2_{FDI}\left(2\phi - 1\right) \lesseqgtr 0. \tag{12}$$

This expression is zero for $\phi = 1/2$ and, as can easily be checked, the second derivative is positive indicating the existence of a minimum. In order words, with two uncorrelated sources of income that have the same variance, splitting the portfolio in half minimizes the overall volatility.

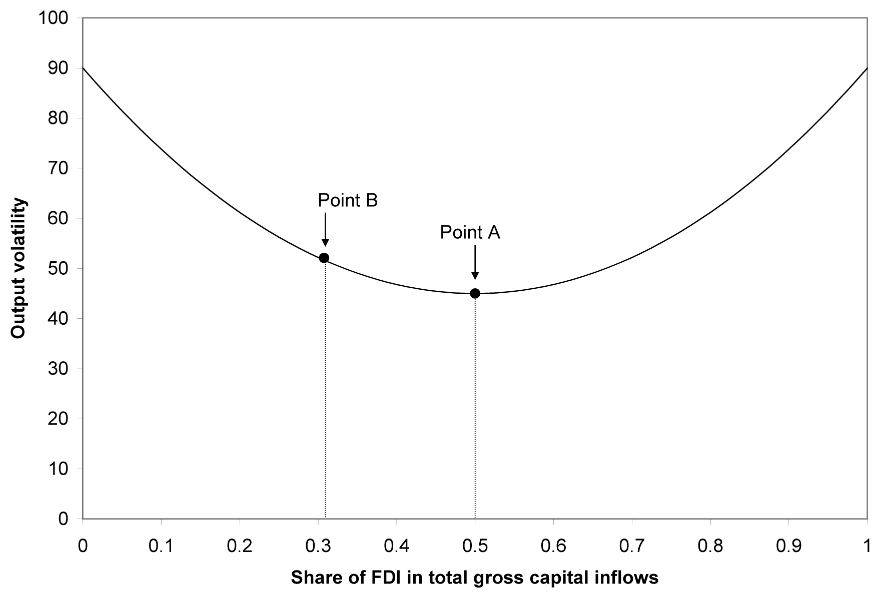
Deviating marginally from $\phi = 1/2$ has, of course, no first-order effect on output volatility. For values of $\phi \neq 1/2$, however, increasing ϕ if $\phi > 1/2$ or reducing ϕ if $\phi < 1/2$ will increase output volatility because the shares are getting farther away from the variance-minimizing mix. Formally:

$$\left.\frac{d\sigma_Y^2}{d\phi}\right|_{\phi>1/2} = 2\tilde{A}\sigma_{FDI}^2\,(2\phi-1) > 0, \tag{13}$$

$$\left.\frac{d\sigma_Y^2}{d\phi}\right|_{\phi<1/2} = 2\tilde{A}\sigma_{FDI}^2\,(2\phi-1) < 0. \tag{14}$$

Figure 1 illustrates this case by plotting σ_Y^2 as a function of ϕ for $\rho = 0$ and $\sigma_{FDI} = \sigma_{OTR} = 30$. We can see that, as equation (A.5) indicates, the variance-minimizing value of ϕ is 0.5 (point A). Given the U-shape of the curve, moving away from point A in either direction increases σ_Y^2. Point B indicates the median value of ϕ in our sample; 0.31. For any ϕ between this value and 0.5, increasing ϕ will reduce output variability.

Figure 1: Output volatility and share of FDI in total gross capital inflows. σ(FDI)= σ(OTR)=30, ρ(FDI,OTR)=0



What happens if we deviate from this benchmark portfolio case in terms of ρ being different from zero or variances not being the same? Cases 4 and 5 study these deviations from Case 3.

- Case 4. Variances are the same but ρ is different from zero (i.e., $\sigma^2_{FDI} = \sigma^2_{OTR}$ and $\rho \neq 0$)

  If the correlation is not zero, then it will still be the case that the value of ϕ that minimizes output volatility is one-half. Indeed, set $\sigma^2_{FDI} = \sigma^2_{OTR}$ in equation (10) and differentiate with respect to ϕ to obtain

  $$\frac{d\sigma^2_Y}{d\phi} = 2\left(\tilde{A}\overline{TF}\right)^2 \sigma^2_{FDI}\,(2\phi - 1)\,(1-\rho) \lesseqgtr 0,$$

  which is zero for $\phi = 1/2$. Intuitively – and as (10) makes clear – a positive correlation increases overall volatility relative to the $\rho = 0$ case but does not change the fact that, since FDI and OTR are not perfectly correlated, the variance-minimizing ϕ is still one-half.

- Case 5. Correlation is zero but variances are different (i.e., $\rho = 0$ and $\sigma^2_{FDI} \neq \sigma^2_{OTR}$). In this case, the variance-minimizing ϕ will change. To see this, set $\rho = 0$ in (10) and differentiate with respect to ϕ to obtain

  $$\frac{d\sigma^2_Y}{d\phi} = 2\left(\tilde{A}\overline{TF}\right)^2 \left[\phi(\sigma^2_{FDI} + \sigma^2_{OTR}) - \sigma^2_{OTR}\right] \lesseqgtr 0.$$

  Setting this expression to zero, we obtain the variance-minimizing value of ϕ:

  $$\phi^{\min} = \frac{\sigma^2_{OTR}}{\sigma^2_{FDI} + \sigma^2_{OTR}}. \tag{15}$$

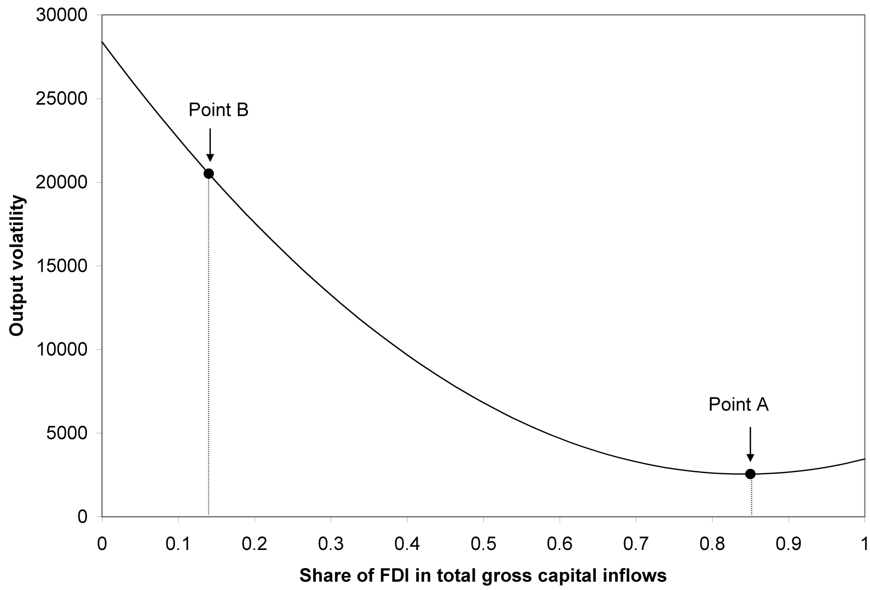
  If $\sigma^2_{FDI} < \sigma^2_{OTR}$, then $\phi^{\min} > 1/2$. Intuitively, if FDI is less volatile than OTR, then it would be optimal to hold more than one-half of the TF as FDI. Even though the variance-minimizing ϕ is larger than one-half, the same intuition developed in Case 3 above holds: deviating from this variance-minimizing value of ϕ will increase overall volatility.

Needless to say, in practice countries cannot choose the variance-minimizing value of ϕ.[13] But all the intuition developed so far will still help us in thinking

[13] Even though we could certainly interpret various measures that emerging countries often adopt to encourage FDI at the expense of other, more volatile, flows as an attempt to increase ϕ and reduce output volatility.

about the data. As an illustration, Figure 2 plots equation (10) for the case of Turkey in which $\sigma_{FDI} = 58.8$, $\sigma_{OTR} = 168.5$, and $\rho = -0.23$.[14] In this case, the variance-minimizing value of ϕ is 0.85, given by point A. Given the U-shape of the curve, moving away from point A in either direction increases σ^2_Y. Point B is the actual value of ϕ for Turkey, $\phi = 0.14$. Since this value of ϕ is less than the variance-minimizing ϕ, increasing ϕ will reduce output volatility. This will be one of the main empirical predictions of our model.

Figure 2: Output volatility and share of FDI in total gross capital inflows. σ(FDI)=58.8, σ(OTR)=168.5, ρ(FDI,OTR)=-0.23



Returning now to the general case captured in equation (10), let us examine how changes in ρ, σ^2_{FDI}, and σ^2_{OTR} affect output volatility. Taking the

[14] See the data section below for the interpretation of the units in which the standard deviations of FDI and OTR are expressed.

corresponding partial derivatives, we obtain

$$\frac{d\sigma_Y^2}{d\rho} = 2\tilde{A}^2\overline{TF}^2\left[\phi\left(1-\phi\right)\sigma_{FDI}\sigma_{OTR}\right] > 0, \tag{16}$$

$$\frac{d\sigma_Y^2}{d\sigma_{FDI}} = 2\tilde{A}^2\overline{TF}^2\left[\phi^2\sigma_{FDI} + \phi\left(1-\phi\right)\sigma_{OTR}\rho\right] \gtrless 0, \tag{17}$$

$$\frac{d\sigma_Y^2}{d\sigma_{OTR}} = 2\tilde{A}^2\overline{TF}^2\left[\left(1-\phi\right)^2\sigma_{OTR} + \phi\left(1-\phi\right)\sigma_{FDI}\rho\right] \gtrless 0. \tag{18}$$

As equation (16) makes clear, a higher ρ always increases output volatility. On the other hand, expressions (17) and (18) indicate that the effects of σ_{FDI}^2 and σ_{OTR}^2 are ambiguous. To understand this ambiguity, think of the case in which $\rho = -1$, $\phi = 0.5$, and $\sigma_{FDI} < \sigma_{OTR}$. Equation (17) then reduces to

$$\frac{d\sigma_Y^2}{d\sigma_{FDI}} = 2\tilde{A}\overline{TF}^2\phi^2\left(\sigma_{FDI} - \sigma_{OTR}\right) < 0.$$

Here a reduction in FDI volatility would *increase* output volatility. Intuitively, with perfect negative correlation between foreign direct investment and portfolio and other investments and $\sigma_{FDI} < \sigma_{OTR}$, FDI volatility is actually a good thing because then FDI can offer more insurance against OTR. In other words, if FDI exhibits very low volatility, then it cannot offset the much higher volatility of OTR.

In the data, however, ρ is on average close to zero (sample median is 0.05), in which case an increase in the volatility of either FDI or OTR will increase output volatility. Intuitively, with zero correlation, higher volatility is unambiguously bad because it contributes to output volatility directly without offering any insurance.

To summarize, the main predictions of our empirical model are as follows:

- Output volatility should be an increasing function of the correlation between FDI and OTR.
- Output volatility should be an increasing function of FDI volatility and OTR volatility (under the assumption that $\rho \geq 0$).
- Output volatility should be a decreasing function of the share of FDI in total capital inflows (under the assumption that the actual value of ϕ is below the variance-minimizing value of ϕ).

III. Data

This study uses a sample of 59 countries: 20 industrial and 39 developing countries for the period 1970-2009.[15] Data frequency is annual. Data for real GDP, gross capital inflows, government spending, inflation, and terms of trade data comes from International Financial Statistics (IFS) and World Economic Outlook (WEO), both from the IMF. For capital flows, we use foreign direct investment, portfolio investment, and other investment gross inflows data. As is common practice (see, for instance, BIS (2009)) we group together portfolio and other investments as being more short-term in nature than FDI and denote this aggregate by OTR.[16]

The standard deviations and correlations of all variables are computed based on their cyclical components. For this purpose, we use the Hodrick-Prescott filter with a smoothing parameter of 6.5 (Ravn and Uhlig, 2002). Since the cyclical component is expressed in terms of percentage deviations of the actual value from the trend, the corresponding standard deviation is also expressed in those terms. For example, the volatility of FDI mentioned above for Turkey ($\sigma_{FDI} = 58.8$) means that, on average, the level of FDI is 58.8 percentage points away from its trend. Given that $\sigma_{OTR} = 168.5$ for Turkey, this implies that portfolio and other investments are almost three times as volatile as FDI.

Another common practice in the literature (see, for instance, Albuquerque, Loayza, and Serven, 2005) is to normalize capital flows such as FDI by dividing them by GDP. The rationale behind this methodology is to control for country size and avoid nonstationarity problems. While helpful in a different context, we feel that this normalization would not be appropriate in our case because the volatility of such a ratio would capture the volatility of both FDI and

[15] Industrial countries comprise Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Netherlands, New Zealand, Portugal, Spain, Sweden, Switzerland, United Kingdom, and United States. Developing countries comprise Argentina, Bangladesh, Brazil, Cambodia, Cape Verde, Chile, Colombia, Costa Rica, Czech Rep., Ecuador, El Salvador, Estonia, Georgia, Guatemala, Hong Kong (SAR China), Hungary, India, Indonesia, Israel, Jordan, Korea, Latvia, Lithuania, Malaysia, Mexico, Mozambique, Pakistan, Panama, Paraguay, Philippines, Romania, Russia, Singapore, South Africa, Sudan, Thailand, Turkey, Uruguay, and Venezuela.

[16] Specifically, OTR includes portfolio investment (i.e, equity and portfolio debt flows) as well as loans, currency, and trade credits.

output. Since the latter will be our dependent variable, our empirical analysis would suffer from endogeneity problems by construction. Moreover, our focus on the cyclical component of capital inflows avoids nonstationarity problems altogether. Notice also that because we measure the cyclical component in terms of percentage deviations of the actual value from the trend, our volatility measures are independent of the size of the economy or capital inflows. Indeed, using cross-country data, we cannot reject the null hypothesis that the correlation between σ_{FDI} and average FDI, as well as the correlation between σ_{OTR} and average OTR, are equal to zero at a 5 percent significance level.

We now turn to a broad look at the data. In particular, we focus on volatility and basic statistics discussed in the previous section. Figure 3 shows output volatility.[17] While output volatility varies substantially across countries, the median is almost twice as large in developing countries as in industrial countries. Figure 4 shows total gross inflows volatility. Not surprisingly, the median of total gross inflows into developing countries is more than one and a half times that of industrial countries.[18]

We now turn to the volatilities of FDI and OTR. Figure 5 shows the ratio of OTR volatility to FDI volatility. The figure is consistent with the idea in the literature that OTR inflows are more volatile than FDI inflows. Indeed, the ratio is larger than one for more than 85 percent of the countries in our sample. The median volatility of OTR is close to 120, compared to less than half (about 44) for FDI. Moreover, the median in developing countries ratios is 76 percent higher than that in industrial economies, reflecting in particular the higher volatility of OTR. In fact, the median FDI volatility is 48 for industrial counties and 41 for developing countries. In sharp contrast, the median OTR volatility is about 30 percent higher in developing countries than in advanced economies (120 for developing countries and 85 for industrial countries).

Figure 6 shows that the share of FDI in total gross capital inflows is typically quite low, with the sample median being 0.32. Indeed, for more than 60 percent of the countries, the share is less than 0.5. Furthermore, the median share is three times as high in developing countries as in industrial countries.

[17] In this and following plots, light (yellow) bars denote developing countries while black bars indicate industrial countries.

[18] Omitting Sudan and Korea (which have very high total gross inflows volatility) does not affect our results.

Figure 3: Output volatility.

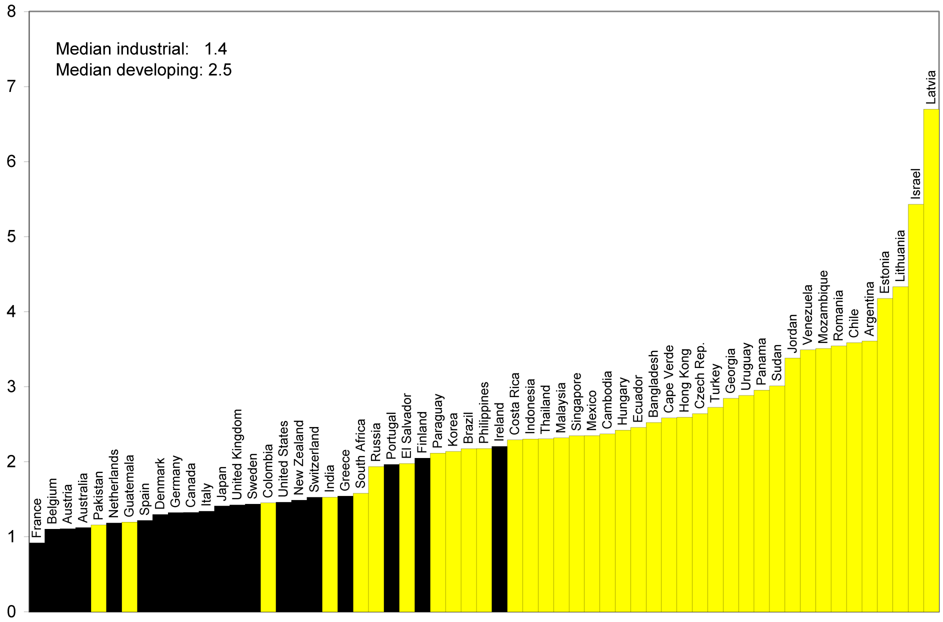
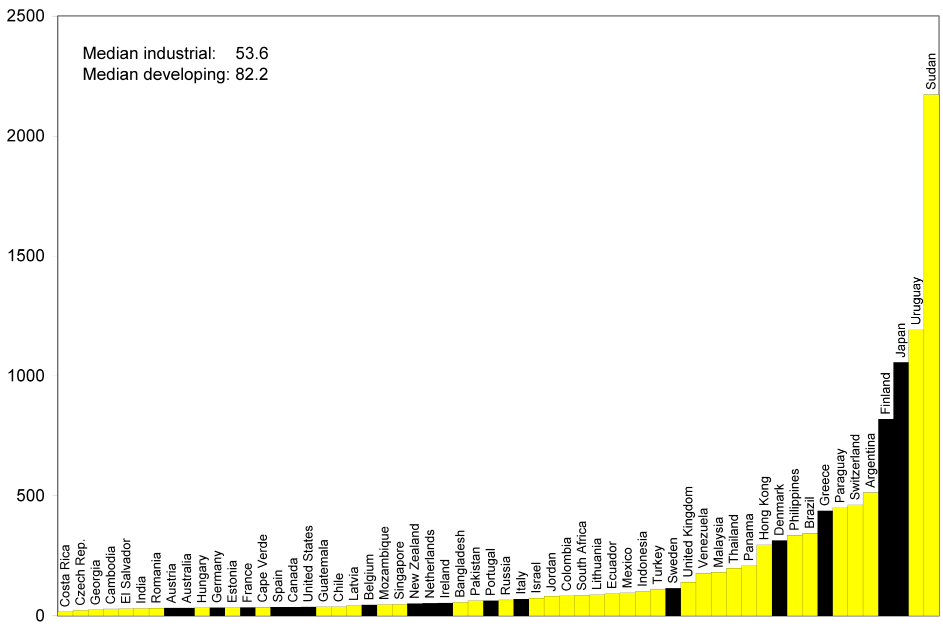
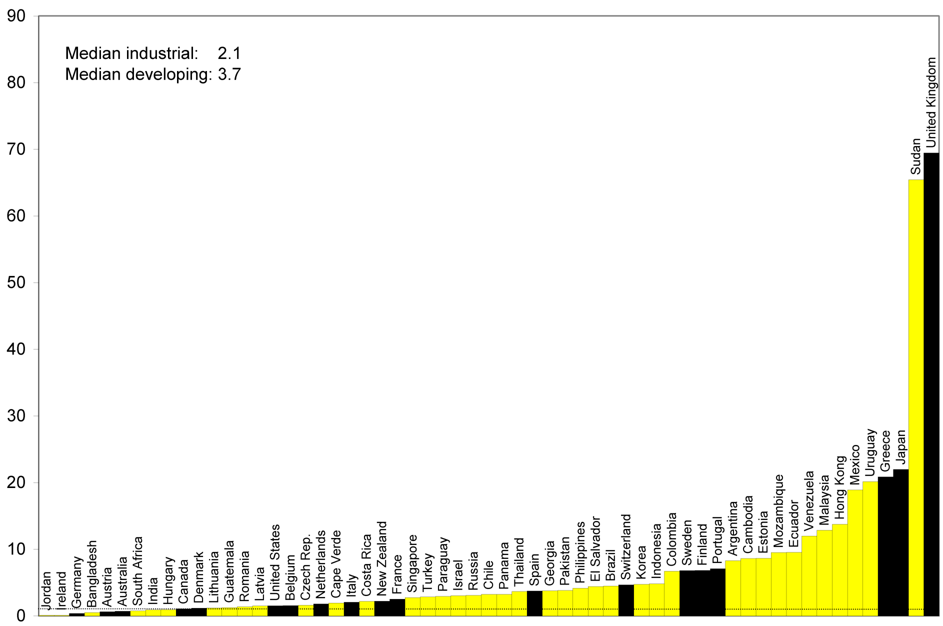


Figure 4: Total gross inflows volatility



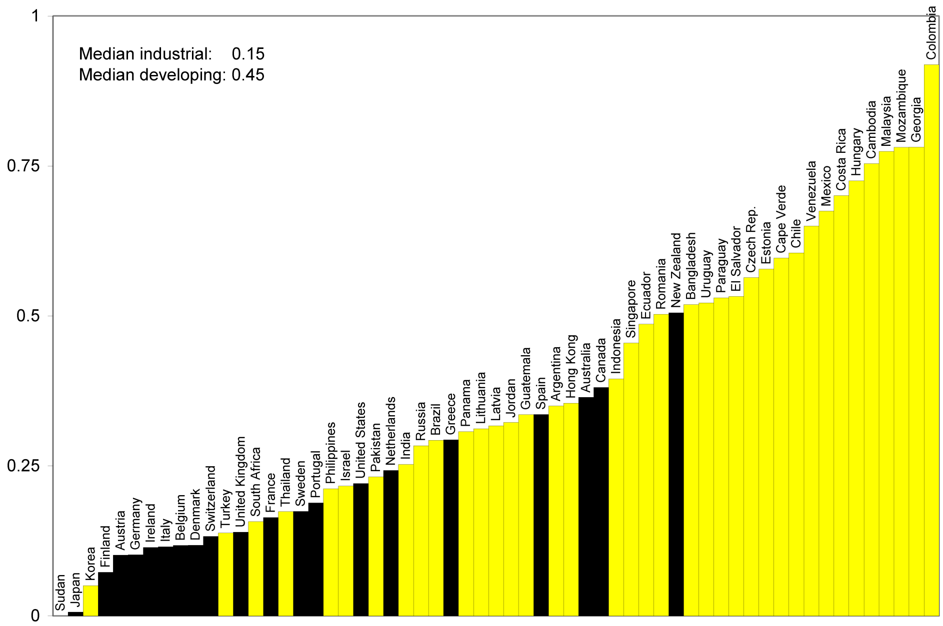
Finally, Figure 7 depicts the correlation between OTR and FDI. We can see wide variation in this figure across countries, with the sample median being 0.05 and the median for developing countries -0.02.

Figure 5: Ratio of OTR over FDI volatilities.



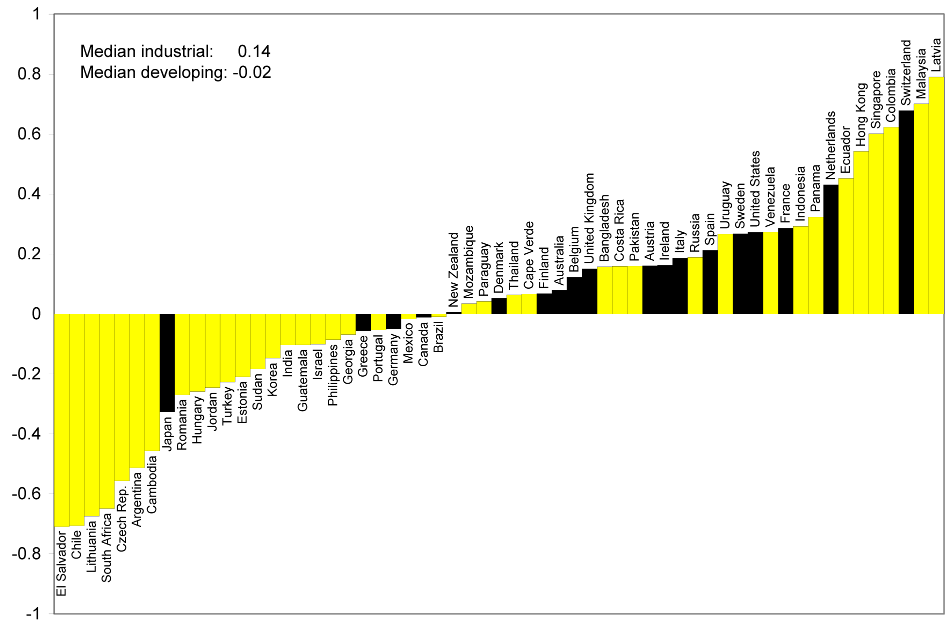
Taking into account the median values of the ratio of OTR volatility to FDI volatility and the correlation between OTR and FDI for industrial and developing countries, we find that the ϕ (i.e., the share of FDI in total capital inflows) that minimizes output volatility (i.e., expression 10) is 0.7 and 0.8 for industrial and developing countries, respectively. These values are much higher than the actual ones: 0.15 for industrial economies and 0.45 for developing countries. The difference in the optimal shares of FDI reflects the fact that (i) the relative ratio of OTR volatility to FDI volatility is higher in developing countries than in industrial ones (3.7 versus 2.1) and (ii) the correlation between OTR and FDI is positive (0.14) for industrial countries but slightly negative (-0.02) for developing countries. In other words, a higher share of FDI

Figure 6: Median share of gross FDI inflows in total gross capital inflows.



in total capital inflows is more beneficial for developing countries than for industrial economies because (i) it reduces total capital flows volatility directly by substituting a more volatile source of capital (OTR) for one that is less volatile (FDI) and (ii) it provides some insurance given the negative (though rather small) correlation.

Figure 7: Correlation between OTR and FDI gross inflows.



IV. Empirical evidence

In this section we test the main empirical implications derived in Section 2. First, output volatility should depend positively on FDI and OTR volatility. Second, output volatility should be an increasing function of the correlation between FDI and OTR. Third, for low values of the FDI share, output volatility should be a decreasing function of the share of FDI in total capital inflows.[19]

We first show our benchmark regressions that link output volatility to the variables highlighted in the empirical model of Section 2. We then control for other variables that, in practice, could affect output variability. We then address endogeneity problems.

IV.1 Basic regressions

Following the empirical growth literature, we use non-overlapping five-year averages. Table 1 reports the basic results using country and five-year fixed effects. Standard errors are robust and we also allow for within-country correlation (i.e., clustered by country). We normalize σ_{FDI} and σ_{OTR} to be between 0 and 100 to make regression coefficients easier to read.[20] Columns 1-5 test the key implications of our model one variable at a time and column 6 tests them all together.

Results are as predicted by our model. Higher FDI and OTR volatility increase output volatility (columns 1 and 2). A higher correlation between FDI and OTR increases output volatility (column 3). When we include the share of FDI in total capital inflows (column 4), it appears not to matter, contrary to our model's prediction. However, as captured by (A.5)-(14), the expected relationship between a higher share of FDI in total inflows and lower output volatility tends to occur when the share is small or, to be precise, smaller than optimal. In the particular case of equal variances and zero correlation, an increase in the share of FDI will reduce output volatility when the initial share is smaller than 0.5 (see equation (14)). To capture this effect, we interact this term with a dummy variable that equals one when the share is smaller than the sample median share (0.32). Column 5 shows that, indeed, after introducing this distinction, output volatility is a decreasing function of the share of FDI in total capital inflows only when its initial value is low. Finally, when all explanatory variables are included (column 6), the size of the coefficients and significance levels remain essentially unchanged.

[19] In principle, one would like to evaluate the interaction effects in a more elaborated way (i.e., by introducing all neccesary interaction terms). Sample size, however, severely restricts our ability to follow such an approach.

[20] After the normalization, σ_{FDI} and σ_{OTR} range between 0 and 14.89 and 0.04 and 100, respectively.

Table 1: Basic regression results. Dependent variable is output volatility.

	(1)	(2)	(3)	(4)	(5)	(6)
σ(FDI)	0.18***					0.16***
	(3.4)					(3.5)
σ(OTR)		0.01***				0.01***
		(3.8)				(3.9)
ρ(FDI,OTR)			0.24*			0.23*
			(1.7)			(1.8)
FDI share				-0.07	0.03	0.03
				(-0.9)	(0.9)	(0.9)
FDI share x low share dummy					-0.56**	-0.53**
					(-2.2)	(-2.1)
R^2	0.12	0.10	0.11	0.11	0.15	0.18
Observations	295	295	295	295	295	295
Countries	59	59	59	59	59	59

Note: Regressions include country and five-year fixed effects. t-statistics are reported in brackets. Standard errors are robust and allow for within-country correlation (i.e., clustered by country). R^2 in all regressions corresponds to within-country R^2. Constant and low share dummy coefficients are not reported. x, *, **, and *** indicate statistically significance at the 15%, 10%, 5%, and 1% levels, respectively.

IV.2 Controlling for other determinants of output volatility

Having established that output volatility depends on the factors predicted by the portfolio model developed in Section 2, we now proceed to control for other factors that could also affect output volatility. While the basic regressions of Subsection 4.1 control for country and five-year fixed effects, other factors such as idiosyncratic external shocks, fiscal policy volatility, and country instability could also affect output volatility.

Fiscal policy volatility is measured using the standard deviation of the cyclical component of government spending. We proxy external shocks volatility using the standard deviation of the cyclical component of terms of trade. Country instability is measured using the average of internal and external conflicts from the International Country Risk Guide (ICRG). Internal conflict refers to political violence within the country and its actual or potential impact on governance. The risk rating assigned is composed of three subcomponents: civil war/coup threat, terrorism/political violence, and civil disorder. External conflict refers to the risk to the incumbent government from foreign action, ranging from non-violent external pressure (diplomatic pressures, withholding of aid, trade restrictions, territorial disputes, sanctions, and so forth) to violent external pressure (ranging from cross-border conflicts to all-out war). The risk rating assigned is composed of three subcomponents: war, cross-border conflict, and foreign pressures. We normalized this variable so that it varies between 0 and 100, with a low value indicating low risk.

Results are reported in Table 2. Columns 1 to 3 show the effects of the control variables one at a time. The three variables have the expected signs: higher fiscal and terms of trade volatility and more country instability increase output volatility. Surprisingly enough, however, terms of trade volatility is not statistically significant. The reason is that we are also including five-year fixed effects. If such fixed effects are not included, then the coefficient of the terms of trade volatility is positive and significant at the 5 percent level. We thus conclude that, while there is some country idiosyncratic variation over time, an important fraction of terms of trade volatility is common to most countries. This is reflected, for instance in the large terms of trade volatility present in the 1970s and early 1980s (as a result of the oil shocks) and in 2005-2009 (generalized rise in commodity prices) compared to the 1990-2004 period.

When including all controls (column 4), fiscal policy volatility becomes insignificant due to its high correlation with country instability.[21] More importantly for our purposes, Column 6 indicates that the size and significance of our four explanatory variables (FDI volatility, OTR volatility, correlation between FDI and OTR, and interacted share of FDI) remain essentially unchanged relative to column 6 in Table 1.

IV.3 Adressing endogeneity

This section addresses potential endogeneity problems. One could reasonably argue that the positive relationship between output volatility and FDI and OTR volatility may reflect the fact that higher GDP volatility increases the volatility of capital inflows. In other words, the causality may run from output volatility to inflows volatility rather than the other way around. In the same vein, reductions in the share of FDI could reflect the reluctance of foreign firms to invest for the long-term in highly volatile economies.

As is the case in the empirical macro literature that has assessed the influence of FDI on economic growth (see, for instance, Lensink and Morrisey, 2001 and Alfaro, 2003), we lack obvious instruments for σ_{FDI}, σ_{OTR}, $\rho(FDI, OTR)$, and $FDI\ share$. We then use three sets of instruments. First, we follow the above-mentioned macro literature in using lagged FDI as an instrument for current FDI. In our case, this amounts to using the lagged five-year average of each portfolio variable as an instrument. For example, we use the σ_{OTR} for the period 1970-1974 to instrument for the period 1975-1979. The Spearman's rank correlation between σ_{FDI} and its lagged five-year value is 0.38. The corresponding correlation is 0.26 for σ_{OTR} and 0.30 for $FDI\ share$. In all cases, the correlation is statistically significant at the 5 percent level. In other words, there seems to be a positive association between the volatilities of capital inflows over time, even at the five-year frequency. Unfortunately, the correlation between $\rho(FDI, OTR)$ and its lagged five-year value is statistically insignificant.

Our second set of instruments uses a geographical/gravity approach aimed at capturing the influence of regional effects. Capital inflows respond to economic

[21] The correlation is 0.40 and statistically different from zero at the one percent level.

Table 2: Regression results with control variables. Dependent variable is output volatility.

	(1)	(2)	(3)	(4)	(5)
σ(gov. Spending)	0.04**			0.02	0.03
	(2.6)			(0.6)	(0.8)
σ(terms of trade)		0.02		0.001	0.02
		(1.0)		(0.03)	(0.7)
Country instability			0.02**	0.03**	0.01
			(2.1)	(2.5)	(0.9)
σ(FDI)					0.17***
					(4.0)
σ(OTR)					0.01***
					(2.9)
ρ(FDI,OTR)					0.24*
					(1.9)
FDI share					0.01
					(0.4)
FDI share x low share dummy					-0.52**
					(-2.0)
R^2	0.07	0.04	0.10	0.11	0.26
Observations	376	388	321	279	225
Countries	49	49	56	47	47

Note: Regressions include country and five-year fixed effects. t-statistics are reported in brackets. Standard errors are robust and allow for within-country correlation (i.e., clustered by country). R^2 in all regressions corresponds to within-country R^2. Constant and low share dummy coefficients are not reported. x, *, **, and *** indicate statistically significance at the 15%, 10%, 5%, and 1% levels, respectively.

and political fundamentals which are often shared by different countries within a region (Calvo and Reinhart, 1996; Fernandez-Arias and Montiel, 1995; Alba, Bhattacharya, Claessens, Gosh, and Hernández, 2000; Corbo and Hernández, 2001). During the 1980s, for example, Latin America experienced such political and economic instability that international investors became reluctant to invest for the long-term. Indeed, $FDI\ share$ was just 0.24 for Latin America during the 1980s, compared to 0.51 during the 1990s, and almost 0.75 during the 2000s. To exploit this geographical dimension, we instrument each portfolio variable using the following expression:

$$I_{it} = \sum_j \frac{1}{dist_{ij}} I_{jt}, \qquad i \neq j,$$

where I_{ij} represents the portfolio variable and $dist_{ij}$ measures the distance between the capital cities of countries i and j. In other words, we instrument a country's five-year observation of each portfolio variable with the weighted sum of such variable for other countries. The weight for each other country decreases with its distance. This gravity approach is thus a more generalized version of the idea behind regional effects. The Spearman's rank correlation between $\rho(FDI, OTR)$ and the suggested geographical instrument is 0.35 and statistically significant at the 5 percent level. The gravity approach proves to be a good strategy to predict the patterns of correlation between FDI and OTR. Unfortunately, the correlations for the other portfolio variables are statistically insignificant.

To complement the two previous sets of instruments, we also rely on the literature regarding the determinants of capital flows. In particular we focus on determinants that may help determine portfolio variables, but not have a direct effect on output. Montiel and Reinhart (1999) find that, by imposing capital controls, countries are able to increase the share of FDI. Generally speaking, policies that punish short-term flows should, in principle, induce foreign investors to increase long-term flows. We use three variables to account for this effect. First, we use the Chinn-Ito index (Chinn and Ito, 2006) to measure *de jure* financial openness. This index, which measures a country's capital account openness, is based on a binary dummy variable that codifies the tabulation of restrictions on cross-border financial transactions reported in the IMF's Annual Report on Exchange Arrangements and Exchange Restrictions. A high value of this index is an indication of low *de jure* financial integration. Second, we use the ratio of total foreign assets and liabilities to GDP from Lane and Milesi-Ferretti (2007) to measure *de facto* financial integration. A high value of this index indicates a high degree of *de facto* financial integration. Lastly, we use the investment profile index from the International Country Risk Guide (ICRG). This investment profile assesses factors affecting the risk to investment that are not covered by other political, economic, and financial risk components. The risk rating assigned is composed of three subcomponents: contract viability/expropriation, profits repatriation, and payment delays. We normalized this variable so that it ranges between 0 and 100, with a low (high) value indicating low (high) risk. We use the five-year lag of these three variables to take care of reverse causality concerns (i.e. ,the possibility that output volatility leads to investment risk). The Spearman's rank correlation between $FDI\ share$ and the five-year lag of the Chinn-Ito index is -0.14, while the correlation with the five-year lag of investment profile is 0.18. In both cases, the correlation is statistically significant at the 5 percent level. These findings support Montiel and Reinhart's (1999) arguments. Moreover, in line with the rationale behind some recent policy measures in countries such as Brazil, more capital controls (i.e., lower *de jure* financial openness) reduce σ_{OTR}. The Spearman's rank correlation between σ_{OTR} and the five-year lag of the Chinn-Ito index is statistically significant and equal to -0.19.

Having checked that the proposed sets of instruments seem to be good predictors for the variables they are instrumenting for, we proceed to estimate instrumental variables regressions. Table 3 shows the instrumental variable regressions. In all cases we cannot reject the overidentification tests at a 5 percent confidence level. The instruments are valid instruments (i.e., uncorrelated with the error term) and the excluded instruments are correctly excluded from the estimated equation. Moreover, as suggested by the discussion above, instrumental variable regressions confirm that in almost all cases the excluded instruments are not weak instruments (i.e., they are strongly correlated with the endogenous regressors). Column 1 shows that our previous empirical findings hold. The only exception is σ_{OTR}: while the sign of the coefficient is positive, it is not statistically significant.[22]

[22] It is worth noting that the sample size of the instrumental variable regression has fallen by almost 45 percent (from 295 and 59 countries in Table 1 to 171 and 38 countries in Table 3).

Table 3: Instrumental variable regression results with control variables. Dependent variable is output volatility

	(1)	(2)	(3)	(4)	(5)
σ(FDI)	0.21***	0.21***	0.18***	0.18***	0.15**
	(4.0)	(3.5)	(3.3)	(2.7)	(2.2)
σ(OTR)	0.02	0.02	0.02	0.02	0.01
	(1.0)	(1.0)	(1.3)	(0.9)	(1.0)
ρ(FDI,OTR)	0.64**	0.61*	0.47*	0.58*	0.46^x
	(2.0)	(1.9)	(1.7)	(1.8)	(1.6)
FDI share	-0.02	-0.02	-0.08	-0.03	-0.04
	(-0.3)	(-0.2)	(-1.1)	(-0.3)	(-0.5)
FDI share x low share dummy	-1.18**	-1.21**	-0.94*	-1.21**	-1.14**
	(-2.4)	(-2.2)	(-1.8)	(-2.4)	(-2.0)
σ(gov. Spending)		0.01			0.01
		(0.5)			(0.7)
σ(terms of trade)			0.07		0.04
		(1.0)	(1.2)		(0.8)
Country instability				0.02***	0.02***
				(2.2)	(2.4)
Overidentification tests	15.2*	14.7*	14.5*	14.9*	13.3
Weak identification tests					
σ(FDI)	30.1***	30.4***	53.0***	25.1***	48.9***
σ(OTR)	1.7^x	1.6^x	1.5	1.5	1.4
ρ(FDI,OTR)	7.3***	7.6***	7.1***	7.3***	7.6***
FDI share	11.1***	10.4***	10.5***	9.6***	8.6***
FDI share x low share dummy	2.2**	1.8*	2.2**	1.9*	1.5
Observations	171	168	171	171	168
Countries	38	38	38	38	38

Note: Regressions include country and five-year fixed effects. t-statistics are reported in brackets. Standard errors are robust and allow for within-country correlation (i.e., clustered by country). R^2 in all regressions corresponds to within-country R^2. Constant and low share dummy coefficients are not reported. The over-identification test is the Chi squared Hansen's J statistic; the null hypothesis is that the instruments are exogenous (i.e., uncorrelated with the error term). The weak-identification test is the first-stage Angrist-Pischke multivariate F test of excluded instruments; the null hypothesis is that the model is weakly identified (i.e., the excluded instruments have a nonzero but small correlation with the endogenous regressors). x, *, **, and *** indicate statistically significance at the 15%, 10%, 5%, and 1% levels, respectively.

We now add control variables. While terms of trade volatility is typically treated as exogenous, this is certainly not the case of government spending volatility and country instability. Indeed, it seems reasonable to argue that higher output volatility might increase government spending volatility and lead to more instability. To account for this potential reverse causality, we use the five-year lag of government spending volatility and country instability. The Spearman's rank correlation between $\sigma_{gov.spending}$ and its five-year lag is 0.56 and the corresponding correlation for country instability is 0.84. In both cases, the correlation is statistically significant at the 5 percent level. Columns 2 to 4 show the results of including each determinant one at a time. Column 5 includes all portfolio and control variables. The inclusion of these determinants does not change the main results reported in column 1.

V. Conclusions

A commonly-held belief is that a larger share of FDI in total capital inflows will reduce output volatility. There is, however, little, if any, formal evidence on this channel. Based on standard portfolio theory, we first develop a simple econometric model that calls attention to some important caveats. In particular, lower FDI volatility will reduce output volatility only if the correlation between FDI and other flows is positive (which is not always the case in the data). Also, a larger share of FDI will reduce output volatility only if the actual share of FDI is below the variance-minimizing share. Our model thus yields three testable implications: (i) output volatility should depend positively on FDI and OTR volatility; (ii) output volatility should be an increasing function of the correlation between FDI and OTR; and (iii) output volatility should be a decreasing function of the share of FDI in total capital inflows (when the initial share is low). We find strong support in the data for all three implications, even after controlling for other factors that influence output volatility and for possible endogeneity problems.

A. Appendix

This appendix develops a simple theoretical model that provides a theoretical illustration of the key assumption in the empirical model – as captured in equation (2) – that there exists a tight link between output and capital inflows. In the theoretical model, such a link will arise endogenously as firms choose whether to finance investment with either short-term or long-term external funding.[23] In the aggregate, the economy uses both sources of finance and changes in, say, the cost of external funding will lead to changes in output, external finance, and its composition.

Consider a small open economy with a continuum of risk-neutral firms that produce the same final (tradable) good, denoted by q, using the same (tradable) capital, denoted by k. Firms are indexed by their productivity parameter, γ ($0 < \gamma < 1$), which is the only source of heterogeneity. Firms "live" for two periods. Firms buy capital before production and hold it for the entire two periods, after which it depreciates completely.

The production function of a γ firm is given by

$$q_t = \alpha k^{\gamma}, \qquad t = 1, 2,$$

where $\alpha > 0$ is a productivity parameter. By construction, output is constant across periods. Firms need to borrow from abroad to finance the purchase of capital. Borrowing can be either short-term or long-term but not a combination of both. Short-term funding (i.e., portfolio investment) requires repayment of principal and interest at the end of the first period. Long-term funding (i.e., foreign direct investment) requires repayment of principal plus interest only after two periods. The one-period short-term and long-term interest rates are, respectively, r^s and r^l. We assume that $r^s < r^l$, reflecting the idea that international lenders may have a preference for a more "liquid" asset.

As an important benchmark, we first solve the firm's problem under short-term financing and no repayment constraint. We then impose the repayment constraint for short-term financing. We then solve for the case of long-term financing. We then compare profits in the two cases (short-term financing

[23] At the cost of complicating the model, we could have included domestic saving as well. Our model, however, can be interpreted as applying to funding needs that go beyond domestic savings, the typical situation for a developing country.

and repayment constraint versus long-term financing) to find out when a firm will chose one or the other. We finally aggregate over all firms to obtain the economy's aggregate capital stock and output and analyze how the equilibrium changes if the cost of long-term financing changes.

A.1 Short-term financing and no repayment constraint

Denote by p the world relative price of q in terms of k and by b_t, $t = 0, 1$ net foreign assets. Think of period 0 as the period in which the capital stock is purchased. Periods 1 and 2 are the periods in which the firm operates (i.e., produces and sells). The flow budget constraints are thus given by

$$\begin{aligned} b_0 &= -k, && \text{(A.1)} \\ b_1 &= (1+r^s)b_0 + p\alpha k^\gamma - \pi_1, && \text{(A.2)} \\ 0 &= (1+r^s)b_1 + p\alpha k^\gamma - \pi_2, && \text{(A.3)} \end{aligned}$$

where π_t, $t = 1, 2$, denotes dividends paid by the firm. Combining these flow constraints, we obtain an intertemporal constraint:

$$\Pi = \frac{(2+r^s)}{(1+r^S)^2} p\alpha k^\gamma - k, \tag{A.4}$$

where $\Pi(\equiv \pi_1/(1+r^s)+\pi_2/(1+r^s)^2)$ is the present discounted value of profits as of time 0.

Firms choose k to maximize (A.4). The first-order condition for capital takes the form:

$$\frac{(2+r^s)}{(1+r^s)^2} p\alpha\gamma k^{\gamma-1} = 1. \tag{A.5}$$

At an optimum, the firm equates the present discounted value of the value of the marginal productivity to the cost of capital. Solving for the capital stock, we obtain

$$k = \left[\frac{(2+r^s)}{(1+r^s)^2}\gamma p\alpha\right]^{\frac{1}{1-\gamma}}. \tag{A.6}$$

Substituting this expression into (A.4), we can write profits as:

$$\Pi = k\left(\frac{1}{\gamma} - 1\right). \tag{A.7}$$

As expected, profits are positive since, by assumption, $\gamma \in (0, 1)$.

In the absence of any additional constraint, all firms would choose short-term financing because, by assumption, it is cheaper than long-term financing. To have a meaningful choice between short-term and long-term financing, we will now introduce a repayment constraint.

A.2 Short-term financing and repayment constraint

Suppose now that a firm can access short-term credit only if it can pay back the loan at the end of the first period. Formally,

$$p\alpha k^{\gamma} - (1 + r^s)k \geqslant 0. \tag{A.8}$$

Let us check if this repayment constraint binds for the unconstrained problem that we just solved. To this effect, substitute (A.6) into the last expression to obtain

$$\frac{1 + r^s}{2 + r^s} \geqslant \gamma.$$

Firms whose γ satisfies this condition will thus still be able to choose short-term financing and remain at the first best because the repayment constraint does not bind. Intuitively, low γ firms optimally choose a low level of capital (i.e., units of capital with high marginal productivity) and are thus more likely to satisfy constraint (A.8) given that the repayment cost per unit of capital $(1 + r^s)$ does not depend the level of capital.

On the other hand, the unconstrained solution for firms with $\gamma > (1 + r^s)/(2 + r^s)$ violates condition (A.8). These firms will thus need to choose between "constrained short-term financing" (i.e., choose the optimal level of capital subject to condition (A.8)) or long-term financing. The trade-off is thus between remaining in a first-best equilibrium but facing a higher cost of capital (long-term financing) or choosing a constrained level of capital but at a lower cost (constrained short-term financing).

If constraint (A.8) binds, then the capital stock is given by

$$k|_{\text{constrained short-term}} = \left(\frac{p\alpha}{1 + r^s}\right)^{\frac{1}{1-\gamma}}. \tag{A.9}$$

If we compare this level of capital with the unconstrained level of capital, given by expression (A.6), for a firm with $\gamma > (1 + r^s)/(2 + r^s)$, we can see that the stock of capital in the constrained case is lower. In other words, to access short-term financing, the firm needs to have a suboptimally low level of capital to generate enough profits in the first period to repay the loan.

A.3 Maximization under long-term financing

Let us now compute profits under long-term financing. The budget constraints remain the same as in (A.1)-(A.3) with r^l in lieu of r^s. Further, since a firm that chooses long-term financing is still operating in a first-best world, the choice of capital will be given by condition (A.6) with r^l in lieu of r^s. Profits will thus be given by (A.7) with the corresponding choice of capital.

A.4 Comparison

Firms with $\gamma > (1 + r^s)/(2 + r^s)$ will choose long-term financing over short-term financing as long as profits are larger:

$$\Pi|_{\text{long-term}} \geqslant \Pi|_{\text{short-term constrained}} .$$

Using equations (A.6) and (A.7), this condition reduces to

$$1 \geqslant \left[\frac{(1+r^l)^2}{(2+r^l)\,(1+r^s)\gamma} \right]^{\frac{1}{1-\gamma}} . \tag{A.10}$$

Suppose to fix ideas that $r^l = r^s$. In this case, this last expression reduces to

$$1 \geqslant \left[\frac{(1+r^l)}{(2+r^l)\,\gamma} \right]^{\frac{1}{1-\gamma}} .$$

Since the choice is only relevant for firms with $\gamma > (1 + r^s) / (2 + r^s)$, the condition will always hold. In other words, if $r^l = r^s$, then all these firms would choose long-term financing because the cost is the same as short-term financing but they are not subject to the repayment constraint (which, by construction, is binding).

But our maintained assumption is, of course, that $r^l > r^s$. In that case, condition (A.10), holding with equality, defines a threshold value of γ, denoted by γ^*, which is given by

$$\gamma^* = \frac{(1+r^l)^2}{(1+r^s)\,(2+r^l)}. \tag{A.11}$$

We now establish the following result:

Claim 1 *Firms with $\gamma \geq \gamma^*$ ($\gamma < \gamma^*$) will choose long-term (short-term) financing.*
Proof. *Consider condition (A.10). Differentiating the right-hand side and evaluating the corresponding expression at $\gamma = \gamma^*$, we obtain*

$$\left.\frac{d\left[\frac{(1+r^l)^2}{\left(2+r^l\right)(1+r^s)\gamma}\right]^{\frac{1}{1-\gamma}}}{d\gamma}\right|_{\gamma=\gamma^*} = \frac{-1}{(1-\gamma)\,\gamma} < 0.$$

Set $\gamma = \gamma^*$ in condition (A.10). By construction, it will hold as an equality. An increase in γ will then reduce the RHS, which means that long-term profits will be higher than constrained short-term profits. The reverse is true for a fall in γ.
■

Intuitively, firms with a large γ (i.e., $\gamma > \gamma^*$) are firms that find it more efficient to operate on a larger scale (and thus would be hurt more by the repayment constraint) and hence would be willing to pay the higher cost of long-term financing in order to not be subject to the repayment constraint. In contrast, smaller firms (i.e., firms with $\gamma < \gamma^*$) would rather not pay the additional cost of financing and choose a second-best level of capital.

From (A.11), we can see that γ^* increases with r^l and decreases with r^s. Intuitively, an increase in r^l makes long-term financing more expensive. As a result, marginal firms will choose to switch to short-term financing (i.e., γ^* increases). Conversely, an increase in r^s makes short-term financing more expensive and hence marginal firms will choose to switch to long-term financing (i.e., γ^* decreases).

A.5 Aggregation

As has been established above, there are three types of firms in this economy depending on the value of γ:

- The range $0 < \gamma \leq \frac{1+r^s}{2+r^s}$ consists of firms that are operating in a first-best world with short-term financing.
- The range $\frac{1+r^s}{2+r^s} < \gamma \leq \gamma^*$ consists of firms that are operating under constrained short-term financing (i.e., these are firms that would violate the repayment constraint if they chose the first-best level of capital).
- The range $\gamma^* < \gamma < 1$ consists of firms that are operating with long-term financing.

Aggregate capita and output are thus given by, respectively,

$$\begin{aligned} \text{Capital} &= \int_0^{\tilde{\gamma}} \left[\frac{(2+r^s)}{(1+r^s)^2} \gamma p \alpha \right]^{\frac{1}{1-\gamma}} d\gamma \\ &+ \int_{\tilde{\gamma}}^{\gamma^*} \left(\frac{p\alpha}{1+r^s} \right)^{\frac{1}{1-\gamma}} d\gamma + \int_{\gamma^*}^1 \left[\frac{(2+r^l)}{(1+r^l)^2} \gamma p \alpha \right]^{\frac{1}{1-\gamma}} d\gamma, \end{aligned} \tag{A.12}$$

$$\begin{aligned} \text{Output} &= \int_0^{\tilde{\gamma}} \alpha \left[\frac{(2+r^s)}{(1+r^s)^2} \gamma p \alpha \right]^{\frac{\gamma}{1-\gamma}} d\gamma \\ &+ \int_{\tilde{\gamma}}^{\gamma^*} \alpha \left(\frac{p\alpha}{1+r^s} \right)^{\frac{\gamma}{1-\gamma}} d\gamma + \int_{\gamma^*}^1 \alpha \left[\frac{(2+r^l)}{(1+r^l)^2} \gamma p \alpha \right]^{\frac{\gamma}{1-\gamma}} d\gamma \end{aligned} \tag{A.13}$$

where $\tilde{\gamma} \equiv (1+r^s)/\,(2+r^s)$.[24]

Since the first two types of firms buy capital with short-term borrowing (denote it by POR), while the last type of firm buys it with long term borrowing (denote it by FDI), we can write

$$POR = \int_0^{\tilde{\gamma}} \left[\frac{(2+r^s)}{(1+r^s)^2} \gamma p \alpha \right]^{\frac{1}{1-\gamma}} d\gamma + \int_{\tilde{\gamma}}^{\gamma^*} \left(\frac{p\alpha}{1+r^s} \right)^{\frac{1}{1-\gamma}} d\gamma, \tag{A.14}$$

$$FDI = \int_{\gamma^*}^1 \left[\frac{(2+r^l)}{(1+r^l)^2} \gamma p \alpha \right]^{\frac{1}{1-\gamma}} d\gamma. \tag{A.15}$$

[24] In our model, firms hold no initial capital so the capital stock can be thought of as investment financed, as made clear below, by POR and FDI.

We thus have an economy with heterogeneous firms in which the composition of external financing is endogenously determined based on each firm's productivity and the cost of short-term and long-term financing. This gives us a simple framework to ask how a change in the cost of long-term financing changes the equilibrium.

A.6 Changes in the cost of long-term financing

What are the effects of a change in r^l? Specifically, suppose that r^l is lower; how does the equilibrium described above change?[25]

Using Leibniz rule, we can compute the changes in capital and output from equations (A.12) and (A.13), respectively:

$$\frac{d\,(\text{capital})}{dr^l} = -\int_{\gamma^*}^{1} \frac{\gamma p \alpha}{1-\gamma}\left[\frac{\left(2+r^l\right)}{(1+r^l)^2}\gamma p \alpha\right]^{\frac{\gamma}{1-\gamma}} \frac{\left(3+r^l\right)}{(1+r^l)^3} d\gamma < 0,$$

$$\frac{d\,(\text{Output})}{dr^l} = -\int_{\gamma^*}^{1} \frac{p\,(\gamma\alpha)^2}{1-\gamma}\left[\frac{\left(2+r^l\right)}{(1+r^l)^2}\gamma p \alpha\right]^{\frac{2\gamma-1}{1-\gamma}} \frac{\left(3+r^l\right)}{(1+r^l)^3} d\gamma < 0.$$

Capital and output thus increase. Intuitively, a fall in r^l affects capital and output through two channels:

- From (A.11), we can see that a higher r^l reduces γ^*. This means that some marginal firms that were relying on short-term financing will switch to long-term financing. At the margin, however, the capital stock of these firms does not change and thus output is not affected.[26]

- The capital stock (and thus output) of firms that rely on long-term financing increases.

[25] Technically, we are solving for the same perfect foresight path for different values of r^l. This can be interpreted as either two economies with different values of r^l or, more appropriately for our purposes, as an unanticipated change in r^l at the beginning of a third period in which the economy goes through the same cycle.

[26] To see that capital does not change, notice that expression (A.6), with r^l in lieu of r^s and evaluated at $\gamma = \gamma^*$, is the same as equation (A.9).

What happens to FDI and POR?

$$\frac{dFDI}{dr^l} = -\left(\frac{d\gamma^*}{dr^l}\right)\left[\frac{(2+r^l)}{(1+r^l)^2}\gamma p\alpha\right]^{\frac{1}{1-\gamma^*}} + \int_{\gamma^*}^{1}\frac{\gamma p\alpha}{1-\gamma}\left[\frac{(2+r^l)}{(1+r^l)^2}\gamma p\alpha\right]^{\frac{1}{1-\gamma}-1}\frac{d\left[\frac{(2+r^l)}{(1+r^l)^2}\right]}{dr^l}d\gamma < 0,$$

$$\frac{dPOR}{dr^l} = \left(\frac{d\gamma^*}{dr^l}\right)\alpha\left(\frac{p\alpha}{1+r^s}\right)^{\frac{\gamma^*}{1-\gamma^*}} > 0.$$

In absolute terms, FDI increases and POR falls. The share of FDI also increases because FDI increases by more than total capital inflows (given that POR falls). Intuitively, FDI increases for two reasons. First, firms that relied on long-term financing are now borrowing more. Second, some marginal firms that were relying on POR have now switched to FDI. The change in FDI is thus larger than the change in the capital stock.

It would be easy to accommodate random changes in r^l in our model as long as firms continue to be risk-neutral. In that case, uncertainty regarding changes in r^l (or r^s for that matter) would not change the firms' behavior derived above (with the expected value of r^l and r^s replacing the actual values). We could imagine that every third period r^l is drawn from some distribution and the above equilibrium materializes. In such a scenario, an increase in the volatility of r^l would lead to higher volatility in output, investment, FDI, POR, and the respective shares. Clearly, being endogenous, the higher volatility of capital inflows or FDI is not "causing" higher output volatility. Rather they are both endogenous responses to the higher volatility in the cost of long-term financing.

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