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Jaroslav Horvath

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Business Cycles, Informal Economy, and Interest Rates in Emerging Countries*

Jaroslav Horvath†

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Abstract

This paper recognizes the importance of a large informal economy and interest rate fluctuations for business cycles in emerging countries. I document (1) a positive relationship between the relative volatility of consumption to output and the size of the informal economy, and (2) countercyclical interest rates in emerging countries. I show that in a two-sector real business cycle model of a small open economy with a poorly measured informal sector, an increase in country interest rate generates a contraction in output, consumption, investment, hours, an improvement in trade balance-to-output ratio, and an expansion of informal sector.

JEL classification: E26; E32; E43; F32; F41

Keywords: Informal Economy; Country Risk; International Business Cycles

*jaroslav.horvath@unh.edu. Department of Economics, University of New Hampshire, 10 Garrison Avenue, Durham 03824, NH.

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1 Introduction

Many researchers have underscored the striking differences between the business cycles in emerging countries (henceforth EC) and in developed countries (henceforth DC).[1] More precisely, in EC the relative volatility of consumption to output is larger than one, net exports are substantially more countercyclical, and EC also exhibit countercyclical real interest rates that lead the cycle. Simultaneously, the size of the informal economy, defined as currently unregistered economic activities contributing to country's output, is on average significantly larger in EC than in DC.[2] This paper aims to assess the contribution of the informal economy and interest rate fluctuations to the behavior of the business cycles in EC.

The main contributions of this paper are twofold. First, the paper documents the importance of the informal economy and fluctuations in country interest rate. I show that there is a positive relationship between the size of the informal economy and relative volatility of consumption to output even after accounting for the fluctuations during global financial crisis.[3] Furthermore, I provide evidence on the countercyclicality and large fluctuations of interest rates in EC.[4] The interest rates in the DC are shown to lag the cycle and to be mildly procyclical. Second, I construct a theoretical model that is calibrated to match the features of Argentine and Mexican business cycles. I find that the model captures several key empirical moments that are usually difficult to replicate in international macroeconomics literature including a relative volatility of consumption to output in excess of one and a countercyclical trade balance-to-output ratio.

The theoretical framework consists of a small open economy model with a formal and an informal sector. The source of uncertainty is sector-specific technology shocks and exogenous fluctuations in country spread. Household chooses to work in the informal sector, which does not pay taxes, and to work in the formal sector, which uses both capital and labor to produce

[1] See for example, Neumeyer and Perri (2005) or Aguiar and Gopinath (2007).
[2] See Schneider et al. (2010) among others.
[3] Restrepo-Echavarria (2014) was one of the first to highlight this relationship.
[4] Neumeyer and Perri (2005) document this relationship for a smaller and shorter sample of EC.

formal goods.[5] Formal sector firms register with the government and hence have access to international markets, where they borrow at an international interest rate to pay a fraction of their wage bill in advance. Informal sector firms use informal labor to produce informal consumption goods. Formal consumption goods can be traded across countries, since the government registers the activity of only formal firms.[6]

I show that if a large fraction of the informal sector remains unmeasured, then an increase in country spread makes the formal consumption goods less desirable, because of the fact that only the formal consumption goods are traded internationally. As a result, agents substitute formal for informal consumption by investing less in the formal sector and by working more in the informal sector.[7] Moreover, an increase in interest rates causes an increase in the borrowing costs for formal firms, which yields a fall in hours worked and output in the formal sector. The trade balance improves as the interest rate increases and consequently the model generates a more volatile consumption than output, countercyclical interest rates, trade balance-to-output ratio, and countercyclical informal sector. On the other hand, a well-measured informal sector decreases the relative volatility of consumption to output, since in this case consumption is the sum of formal and informal consumption, and formal and informal consumptions are more negatively correlated than formal and informal outputs.[8] When abstracting from the productivity shocks, the results show that the contribution of interest rates to business cycle fluctuations is about 16 and 10 percent for Argentina and Mexico, respectively. This is consistent with the empirical evidence of Akinci (2013) who reports that country spread shocks explain about 15% of changes in macroeconomic activity in EC. More importantly, my model shows that in relative terms the interest rate shocks alone are still capable of accounting for key features of economic fluctuations in EC.

[5]Maloney (1999) and Pratap and Quintin (2006) report that there is no significant fragmentation of labor market between formal and informal sectors in Argentina and Mexico.

[6]Gasparini and Tornarolli (2009) show that non-tradable sectors consist mostly of informal labor force.

[7]The substitutability between formal and informal consumption is conceivably high. For example, fruit and vegetables sold by a street vendor (informal consumption goods) are almost of identical quality as the ones supplied by a grocery store (formal consumption goods). See Section 4 for further details.

[8]This is due to the increase in trade balance after an increase in interest rates.

This paper deviates from existing literature in two main ways. First, the size of the informal sector is taken as given. This paper does not investigate the factors that give rise to a large informal sector or cause its growth or decline. The strand of literature studying the evolution of the informal sector includes, for example, Schneider and Enste (2000), who examine the most common causes of informal economy such as tax burden, labor market regulation, and the social welfare system. The purpose of this paper is to show that if the informal sector is mismeasured, then in the presence of interest rate shocks, the volatility of consumption is naturally higher than that of output and the economy exhibits countercyclical real interest rates, and countercyclical trade balance-to-output ratio. Second, the country interest rate is a product of an international rate and a country spread. The international rate is proxied by the 3-month U.S. Treasury bill rate and is assumed to be constant, which is a standard assumption for small open economy models. As a result, a shock to country's interest rate is modeled as exogenous fluctuations in the country spread process, which is estimated using the J.P. Morgan EMBI+ data. Aguiar and Gopinath (2006), for instance, endogenize the real interest rates by modeling a small open economy with default and highlight the countercyclicality of real interest rates and net exports in EC in a setting with a stochastic trend and one period bonds. In comparison, I follow the evidence of Akinci (2013) and Longstaff et al. (2011), who show that in EC the main source of variation in country spreads is exogenous events unrelated to local economic conditions. Akinci (2013) finds that about two thirds of the variance of local macroeconomic variables in EC is explained by the impact of global financial conditions, proxied by the U.S. BAA corporate spread or the VIX index, on the movements in the country spread. Longstaff et al. (2011) use a panel of credit default swap data and document that sovereign credit risk is driven markedly more by global factors than by country-specific economic conditions. Fernandez-Villaverde et al. (2011) abstract from the informal sector and highlight the impact of fluctuations in the volatility of country spread on the size and pattern of business cycles in EC.

My work is related to the literature on home production such as Benhabib et al. (1991), who study a closed economy and examine the effects of relative productivity shocks on the relative volatility of consumption to output in the U.S. economy. The difference between their work and this paper is that unlike home produced goods, informal goods are sold in particular markets, which implies that they should be accounted for in country's national accounts. Therefore, countries should recognize the importance of the large informal economy for their macroeconomic fluctuations.

This paper also complements the work of Neumeyer and Perri (2005) and Restrepo-Echavarria (2014). Neumeyer and Perri (2005) consider a standard real business cycle small open economy environment augmented by a working capital assumption and by assuming GHH preferences first introduced by Greenwood et al. (1988). Moreover, they introduce U.S. interest rate shocks, country spread shocks, and technology shocks. In contrast, I focus on the more standard Cobb-Douglas preferences that allow consumption to be negative related to labor supply, and account for the large informal sector in EC. To my knowledge, this paper is the first to analyze the response of economic quantities to interest rate shocks in a two-sector model economy. Restrepo-Echavarria (2014) introduces an informal sector into a small open economy model and considers relative productivity shock in the informal sector. Variation in the size of the informal sector together with the relative productivity shock allow her to explain a large fraction of heterogeneity in the relative volatility of consumption to output across emerging and some developed countries. My work investigates country interest rate and sector-specific productivity shocks and additionally sheds light on the cyclicality of interest rates and trade balance in EC.

The remainder of the paper is organized as follows. Section 2 provides empirical evidence on informal economy and interest rate fluctuations. Section 3 introduces the theoretical framework. Section 4 describes the functional forms and calibration. Section 5 presents the main model findings and sensitivity analysis. Section 6 concludes.

2 Empirical Evidence

This section presents examples of market transactions that constitute informal economy activities, common approaches used to quantify the size of informal economy, and provides reasons for mismeasurement of the informal economy. It also documents the positive relationship between the size of the informal economy and relative volatility of consumption to output. Lastly, the section contrasts the salient features of business cycles in emerging and developed countries including the behavior of country interest rates.

2.1 Informal Economy and Business Cycles

To assess the size of informal sector, economists define the informal sector as the legal value-added activities that are not registered by the government, but would otherwise contribute to country's GDP. Table 1 provides various examples of informal economy activities and demonstrates that the informal economy solely consists of legal activities such as unreported income from self-employment or tax avoided employee discounts. It emphasizes that the definition of informal economy does not comprise illegal activities such as drug dealing, gambling, or smuggling.

As Restrepo-Echavarria (2014) points out, countries measure their national accounts by following the method in the "Systems of National Accounts, 1993" by OECD (2000). First, countries use the value added approach to compute the income side of their national accounts and then they calculate investment, net exports, and government spending using the expenditure approach. As a result, consumption is measured as a residual. Many countries, especially the more developed ones, also follow the methods on how to measure informal economy published in a handbook by the OECD (2002) to better quantify the size of their informal economy.

Countries use various direct and indirect approaches to gauge the size of the informal sector. One of the most common direct approaches is the conduction of sample surveys.

Table 1: A Taxonomy of Types of Underground Economic Activities

Type of activity	Monetary transactions		Non monetary transactions	
Illegal activities	Trade with stolen goods; drug dealing and manufacturing; prostitution; gambling smuggling; fraud; etc.		Barter of drugs, stolen goods, smuggling etc. Produce or growing drugs for own use. Theft for own use.	
	Tax evasion	Tax avoidance	Tax evasion	Tax avoidance
Legal activities	Unreported income from self-employment; Wages, salaries and assets from unreported work related to services and goods	Employee discounts, fringe benefits	Barter of legal services and goods	All do-it-yourself work and neighbor help

Source: Lippert and Walker (1997, p.5) with additional remarks.

However, these depend on the questions asked and on the honesty of respondents, since people are frequently afraid of answering the questions truthfully. Moreover, most surveys cover only urban areas of a given country, which brings the reliability of this approach into question, because majority of the informal sector is located in rural areas.[9] The survey method requires substantial financing and therefore its coverage, especially in many EC, is poor. This is one of the main reasons why a large fraction of informal economy in EC stays unmeasured.

Researchers also employ several indirect approaches to measure the size of the informal economy. For example, the currency demand approach introduced by Cagan (1958) and later extended by Tanzi (2014) assumes that cash is the main source of payment in informal economy. As a result, this method analyzes the correlation between currency and the size of shadow economy by controlling for other factors such as interest rates and payment habits. The difficulty with this approach is that not all informal activities need cash to operate. Also, an increase in demand for money may mostly reflect just a slowdown in demand deposits rather than an increase in currency demand in the informal economy. Another commonly used indirect approach is the Kaufmann-Kaliberda (1996) method. This technique assumes electricity consumption to be the best physical indicator of GDP and the elasticity of elec-

[9]Mogensen et al. (1995) discuss this method in further detail.

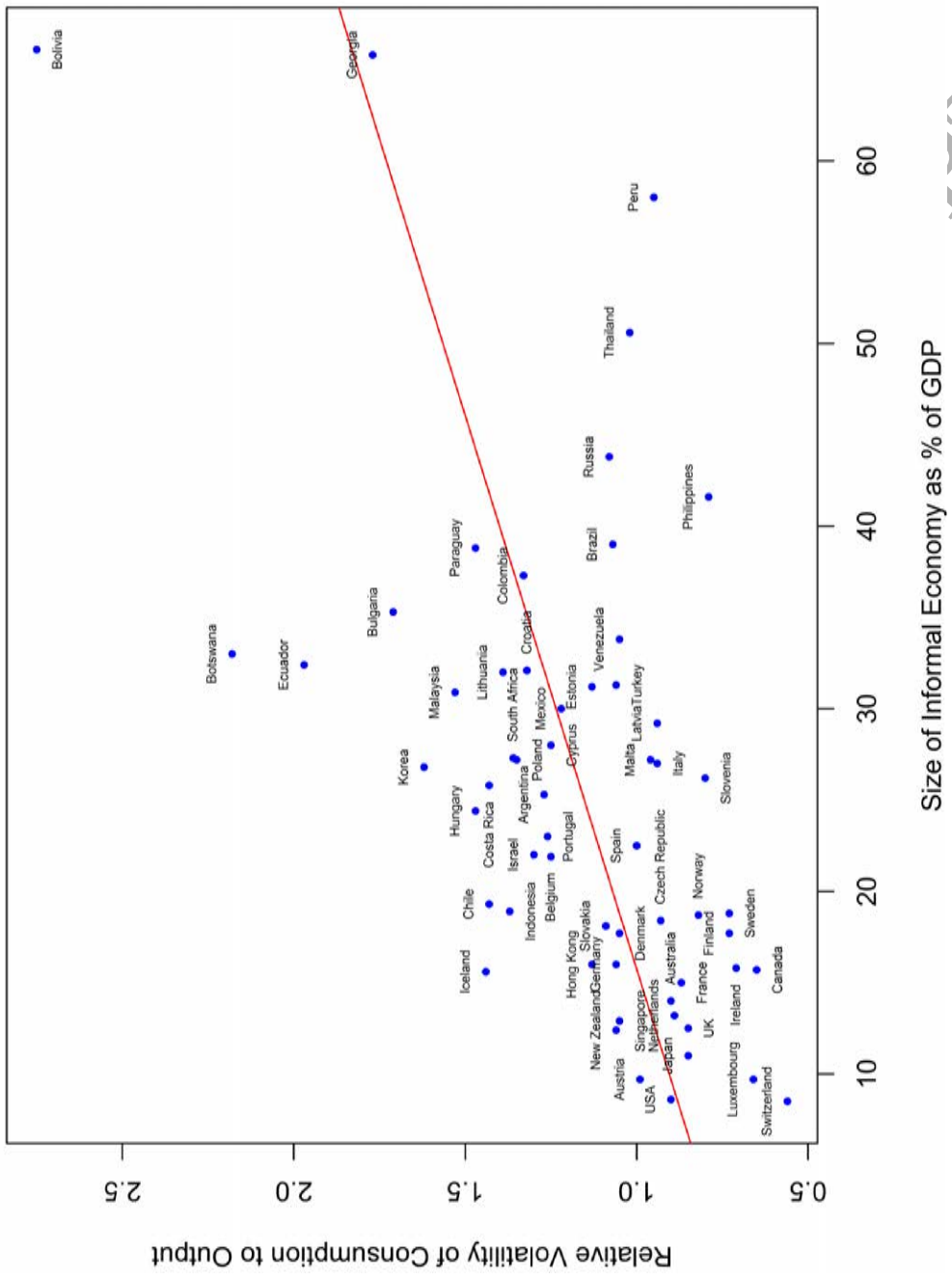
tricity over GDP ratio to be close to one. This means that if there is a greater increase in the electricity consumption growth than in GDP growth, then the growth differential is attributed to an increase in the size of informal sector. The weak points of this method are that electricity is not the only source of energy for informal activities and the efficiency of electricity use and the elasticity of electricity to GDP ratio vary across sectors and time. Many researchers also use the Multiple-Indicator-Multiple-Cause (MIMIC) approach that treats the informal economy as a latent variable and connects it to several indicators and causes such as the degree of regulation, worker participation, and "tax morality". However, Helberger and Knepel (1988), for example, criticize this method by stating that it is potentially unstable over time and also for inclusion of different variables.[10] Altogether, none of these approaches is perfect and the point is that measuring informal economy is costly and challenging. Most EC exhibit large informal economies, but simultaneously allocate little resources to capture the size of their informal economy in their national accounts. For this reason, a substantial fraction of the size of informal economy remains unmeasured.

Many economic models disregard the presence of a large informal sector in EC. Figure 1 shows that accounting for the large informal sector in EC may help in explaining the magnitude of business cycle fluctuations in these countries. I use the data from Table 3.3.6 in Schneider et al. (2010) to obtain the average values for the size of informal economy measured as a percentage of country's GDP over the 1999-2007 period. The size of the informal economy is estimated for 151 countries using the MIMIC method, which assumes that the size of the informal economy has multiple causes.[11] To compute the relative volatility of consumption to output, I source national accounts data from the International Financial Statistics (IFS) and the Organization for Economic Co-operation and Development (OECD) databases for countries that are included in Schneider et al.'s (2010) Table 3.3.6 and that

[10] Schneider and Enste (2000) provide additional description of the above approaches.

[11] Schneider (2004) uses an average of MIMIC and currency demand methods to measure the size of informal economy and his reported numbers are virtually identical to the ones reported in Schneider et al. (2010), who use only the MIMIC approach.

Figure 1: Relative Volatility of Consumption to Output versus Informal Economy (Correlation = 0.55)



Notes: Informal economy is measured as the average size in percentages of the informal economy relative to country's GDP over the 1999-2007 period. Source: Schneider et al. (2010). The relative volatility of consumption to output is computed for the 1990Q1-2016Q4 period and for countries that have at least 10 years of available data. The red line is obtained by regressing the relative volatility of consumption to output onto the size of informal economy.

have at least 10 years of data available i.e. the starting year is at least 1997.[12] This ensures that the sample contains more countries, especially the less developed ones, and yields a total of 58 countries. Since the average size of the informal economy is computed over the 1999-2007 period, I compute the relative volatilities of consumption to output for the centered sample window from 1990Q1 to 2016Q4. Figure 1 reveals that there is a substantial positive correlation between the relative volatility of consumption to output and the size of the informal economy. The red line in Figure 1 denotes the regression line of the relative consumption to output volatility onto informal economy size. This correlation amounts to about 0.55 with a standard error of 0.13 based on bootstrapping with 5000 repetitions.[13] The correlation remains statistically different from zero and high at 0.49 when I abstract from two outliers - Bolivia and Peru - identified by Cook's distance statistic.[14] In summary, Figure 1 depicts that on average the relative volatility of consumption to output tends to increase with the size of the informal sector and shows that it may be natural for countries with large informal sectors to have a larger volatility of consumption than that of output.

2.2 Interest Rates

The large relative volatility of consumption to output is not the only distinctive feature of the behavior of business cycles in EC. As demonstrated by Neumeyer and Perri (2005), the behavior of country interest rates in EC and DC differs greatly. To highlight the differences in the business cycle and interest rate patterns, I explicitly divide countries into EC and DC based on the World Bank's classification method. A country is classified as a small open emerging country (EC) if it has not been classified as a high-income country for the most part of my sample by the World Bank and simultaneously has adequate national

[12]Reasonable changes in the cutoff year have negligible effect on the correlation between relative volatility of consumption to output and the size of informal economy.

[13]This correlation is statistically significant with a p-value practically zero. Furthermore, it remains unchanged at 0.55 when I use a narrower centered sample window from 1994Q1 to 2012Q4.

[14]Using different data sources and sample periods, Restrepo-Echavarria (2014) finds a correlation of about 0.75.

Table 2: Business Cycles in Emerging and Developed Countries: Volatilities

Emerging Countries	$\sigma(y)$	$\sigma(c)$	$\sigma(i)$	$\sigma(R)$	$\sigma(c)/\sigma(y)$	$\sigma(i)/\sigma(y)$	$\sigma(tb/y)/\sigma(y)$	$\sigma(R)/\sigma(y)$
Argentina	4.76	6.06	11.38	13.74	1.27	2.39	0.94	2.89
Brazil	1.97	2.11	4.69	3.79	1.07	2.38	1.04	1.93
Chile	1.80	2.58	7.19	0.74	1.43	3.99	2.87	0.41
Colombia	3.68	4.88	10.38	2.18	1.33	2.82	0.67	0.59
Ecuador	2.07	4.06	7.88	7.39	1.97	3.81	2.03	3.58
Hungary	1.58	2.33	4.85	1.46	1.47	3.06	2.80	0.92
Malaysia	2.46	3.76	10.59	1.57	1.53	4.30	3.88	0.64
Mexico	2.20	2.67	7.01	2.62	1.22	3.19	0.71	1.19
Peru	2.78	2.63	7.17	2.15	0.95	2.58	1.44	0.77
Philippines	1.32	1.04	5.47	1.66	0.79	4.13	2.73	1.25
South Africa	1.29	1.76	5.53	1.01	1.36	4.29	1.99	0.78
Turkey	3.69	3.90	10.53	2.41	1.06	2.85	0.78	0.65
Venezuela	5.27	5.53	15.74	4.53	1.05	2.99	3.02	0.86
Mean	2.68	3.33	8.34	3.48	1.27	3.29	1.91	1.27
Median	2.33	3.00	7.54	2.30	1.27	3.13	1.95	0.89
Developed Countries								
Australia	0.85	0.76	3.81	0.47	0.90	4.50	4.37	0.55
Austria	1.16	1.15	3.81	0.58	1.00	3.30	1.38	0.50
Belgium	1.05	1.31	3.50	0.68	1.26	3.35	1.60	0.65
Canada	1.17	0.76	3.45	0.60	0.65	2.95	3.31	0.51
Denmark	2.50	2.63	5.38	0.78	1.05	2.15	0.61	0.31
Finland	2.19	1.61	5.97	0.84	0.73	2.72	1.81	0.38
Netherlands	1.22	1.08	4.11	0.59	0.89	3.37	1.83	0.48
New Zealand	1.42	1.50	6.10	0.56	1.06	4.29	2.29	0.39
Norway	1.42	1.18	5.65	0.73	0.83	3.98	4.29	0.51
Portugal	1.37	1.72	5.14	0.52	1.26	3.76	2.70	0.38
Spain	1.38	1.38	4.60	0.70	1.00	3.33	1.89	0.50
Sweden	1.75	1.26	4.39	0.70	0.72	2.51	1.06	0.40
Switzerland	1.06	0.59	2.71	0.31	0.56	2.55	3.48	0.29
Mean	1.43	1.30	4.51	0.62	0.92	3.29	2.36	0.45
Median	1.37	1.28	4.45	0.61	0.91	3.32	2.09	0.47

Notes: $\sigma(x)$ denotes the volatility of variable x. $y, c, i, tb/y, R$ denote output, consumption, investment, trade balance-to-output ratio, and country interest rate.

accounts and interest rate data. This results in 13 emerging countries.[15] The sample of DC is constructed following Aguiar and Gopinath (2007) and includes countries classified as high-income countries by the World Bank and countries that are considered to be "small".

[15]My sample contains 10 out of 13 EC included in the sample of Aguiar and Gopinath (2007).

Table 3: Business Cycles in Emerging and Developed Countries: Correlations

Emerging Countries	$\rho(c,y)$	$\rho(i,y)$	$\rho(tb/y,y)$	$\rho(R,y)$	$\rho(c,R)$	$\rho(i,R)$	$\rho(tb/y,R)$
Argentina	0.95	0.89	-0.48	-0.54	-0.54	-0.49	0.75
Brazil	0.73	0.72	-0.20	-0.29	-0.16	-0.20	0.04
Chile	0.50	0.55	-0.02	-0.26	0.00	-0.05	-0.21
Colombia	0.94	0.71	-0.17	0.09	0.17	-0.16	0.12
Ecuador	0.59	0.77	-0.37	-0.48	-0.43	-0.32	0.35
Hungary	0.54	0.45	-0.15	-0.50	-0.37	-0.18	0.75
Malaysia	0.63	0.76	-0.30	-0.65	-0.50	-0.54	0.36
Mexico	0.89	0.86	-0.51	-0.39	-0.48	-0.34	0.52
Peru	0.60	0.80	-0.09	-0.26	0.02	-0.13	-0.47
Philippines	0.43	0.40	-0.07	-0.32	-0.04	-0.14	-0.32
South Africa	0.77	0.71	-0.27	-0.05	-0.02	0.50	-0.04
Turkey	0.85	0.90	-0.51	-0.53	-0.55	-0.56	0.87
Venezuela	0.89	0.89	-0.28	-0.35	-0.37	-0.31	-0.04
Mean	0.72	0.72	-0.26	-0.35	-0.25	-0.22	0.21
Median	0.72	0.74	-0.27	-0.35	-0.31	-0.21	0.16
Developed Countries							
Australia	0.49	0.70	-0.10	0.13	0.26	0.25	0.40
Austria	0.53	0.62	0.12	0.12	0.01	0.05	-0.52
Belgium	0.59	0.57	-0.11	0.01	-0.02	0.03	0.01
Canada	0.72	0.71	0.07	0.24	0.19	0.14	0.44
Denmark	0.87	0.65	-0.03	0.10	0.06	0.12	-0.18
Finland	0.70	0.81	-0.01	-0.09	-0.06	-0.04	0.06
Netherlands	0.79	0.77	-0.02	0.20	0.12	0.16	-0.74
New Zealand	0.76	0.79	-0.20	0.25	0.37	0.28	0.44
Norway	0.54	0.40	-0.02	-0.02	0.03	0.03	0.64
Portugal	0.84	0.89	-0.28	-0.04	0.02	0.00	-0.24
Spain	0.88	0.86	-0.37	0.05	0.02	0.02	-0.06
Sweden	0.60	0.78	0.08	-0.14	-0.07	-0.24	-0.27
Switzerland	0.47	0.79	0.08	0.29	0.15	0.17	-0.54
Mean	0.67	0.72	-0.06	0.08	0.08	0.08	-0.04
Median	0.69	0.74	-0.03	0.09	0.05	0.06	-0.05

Notes: $\rho(x,z)$ denotes the correlation between variables x and z. $y, c, i, tb/y, R$ denote output, consumption, investment, trade balance-to-output ratio, and country interest rate.

In other words, the sample of DC excludes all G7 countries except Canada. The aim of the division of countries into two groups is to contrast the behavior of business cycles and interest rates in EC and DC by extending the sample to account for effect of the recent global financial crisis on the countries' national accounts and interest rates.

I obtain the National Accounts data from IFS and complement it from OECD if the sample windows are comparable. The Venezuelan data comes from the Economic Commission for Latin America and the Caribbean (ECLAC). The starting year for DC is 1990Q1 to be consistent with Figure 1 and to make the data more comparable across the two groups of countries, since the sample for emerging economies' data commences between 1990Q1 and 1996Q1.[16] Consumption is measured as household consumption and non-profit institute expenditures if household consumption expenditure on is own is unavailable. Investment is captured by gross fixed capital formation. Real data is obtained using country-specific GDP deflator or in chained volume estimates in the case of OECD data. The data is also deseasonalized using the U.S. Census Bureau's X-12 ARIMA seasonal adjustment program and detrended using the Hodrick-Prescott (HP) filter with a smoothing parameter of 1600. Following the approach of Uribe and Yue (2006), country interest rate in EC is computed as the sum of an international risk-free rate proxied by the U.S. real interest rate and of the country spread measured by the J.P. Morgan's EMBI+ spread data.[17] The U.S. real interest rate is obtained by deflating the U.S. nominal three-month T-bill rate by the average of the U.S. CPI inflation rate in the current and previous three quarters.[18] Country interest rate in DC is proxied by the three-month treasury rates deflated by an average inflation in the current and previous three quarters, similarly to Neumeyer and Perri (2005). All interest rate data is downloaded from the Global Financial Data (GFD).

Table 2 reports the volatilities of output, consumption, investment, trade balance-to-output ratio, and interest rate in both groups of countries. It emphasizes that the business cycles in EC tend to be more volatile. The relative volatility of consumption to output is on average larger than one in EC whereas it is less than one in DC. This result is in line

[16]Main findings including that the relative volatility of consumption to output is greater than one on average in EC and less than one in DC are robust to using 1980 as a starting year for countries that have the available data. The appendix lists more details on the sample windows.

[17]The appendix lists the sample windows for individual countries.

[18]The measure of expected inflation is motivated by the evidence that the U.S. inflation rate follows a random walk. See Atkeson and Ohanian (2001). Fernandez-Villaverde et al. (2011) apply identical approach to their monthly country spread data.

with Neumeyer and Perri (2005) and Aguiar and Gopinath (2007). Furthermore, Table 2 shows that the interest rates fluctuate significantly more in EC than in DC, both in absolute terms and also relative to output. Lastly, although the volatility of output and investment is higher in EC, the relative volatility of investment to output is similar between the two country groups.

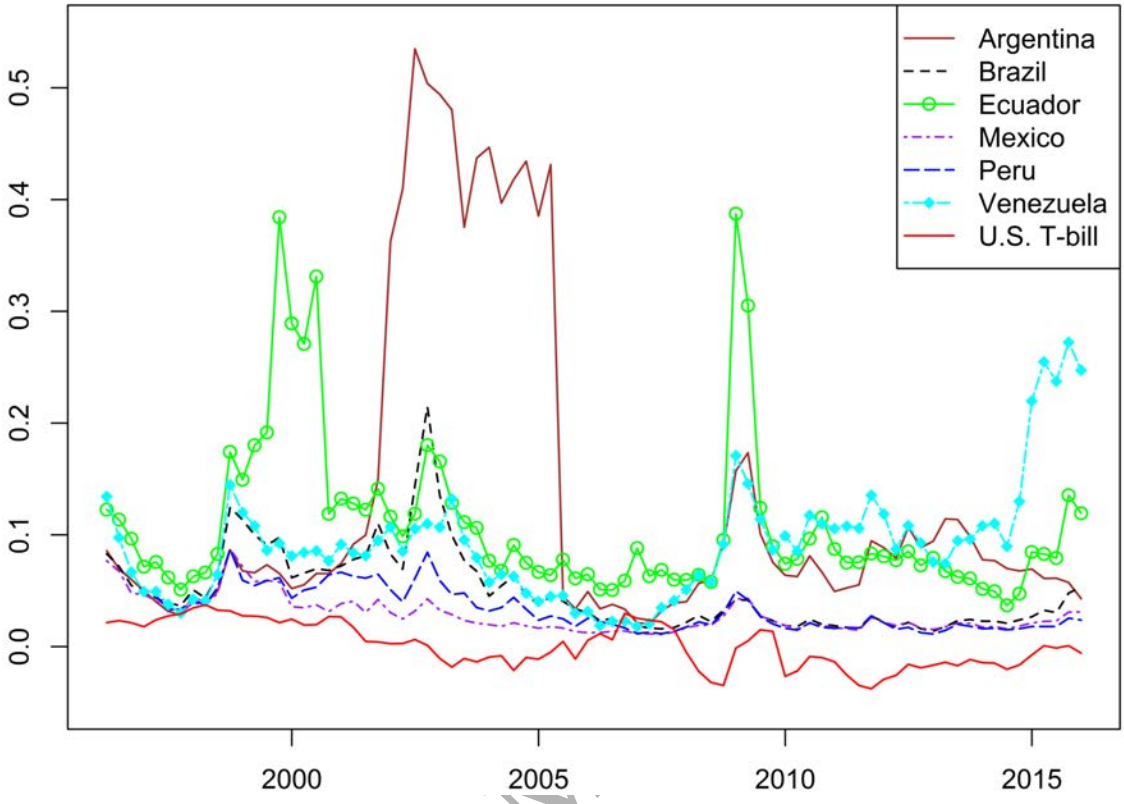
Table 3 lists the correlations between economic quantities with the interest rate and output. The table demonstrates two additional salient features of business cycles in EC. First, EC tend to exhibit more strongly countercyclical trade balance. The mean correlation between the trade balance-to-output ratio and output is about -0.26 in EC compared to -0.06 in DC. Second, country interest rates tend to be countercyclical in EC and mildly procyclical in DC. The correlation between country interest rate and output is negative for all EC except for Colombia while this correlation is positive for nine out 13 DC.

Large swings in interest rates, at which countries borrow internationally, are another key feature of business cycles in EC. Figure 2 displays the historical evolution of the annualized U.S. real three-month T-bill rate and country spreads of EC with uninterrupted data from 1996Q1-2015Q4 to further illustrate the extent of interest rate dynamics in these countries. Figure 2 shows that the international real interest rate, proxied by the U.S. real interest rate, is relatively low and constant, while the country spreads tend to be high and fluctuate substantially.[19] For example, the Argentine partial default on its debt in 2001 resulted in the country spreads over 50 percent and the Venezuelan political turmoil in 2015 led to country spreads close 30 percent.

To provide supplementary evidence that country interest rates may play a key role in explaining the behavior of business cycles in emerging countries, Figure 3 displays the co-movement of detrended real output and country interest rates for selected emerging countries. Figure 3 demonstrates that in addition to facing volatile interest rates, EC face interest rates that tend to be countercyclical. More specifically, the correlations between a country's in-

[19]Fernandez-Villaverde et al. (2011) formally isolate shocks to interest rate volatility and demonstrate that they account for a significant fraction of business cycle fluctuations in EC.

Figure 2: Historical Evolution of the U.S. Real Interest Rate and Emerging Country Spreads

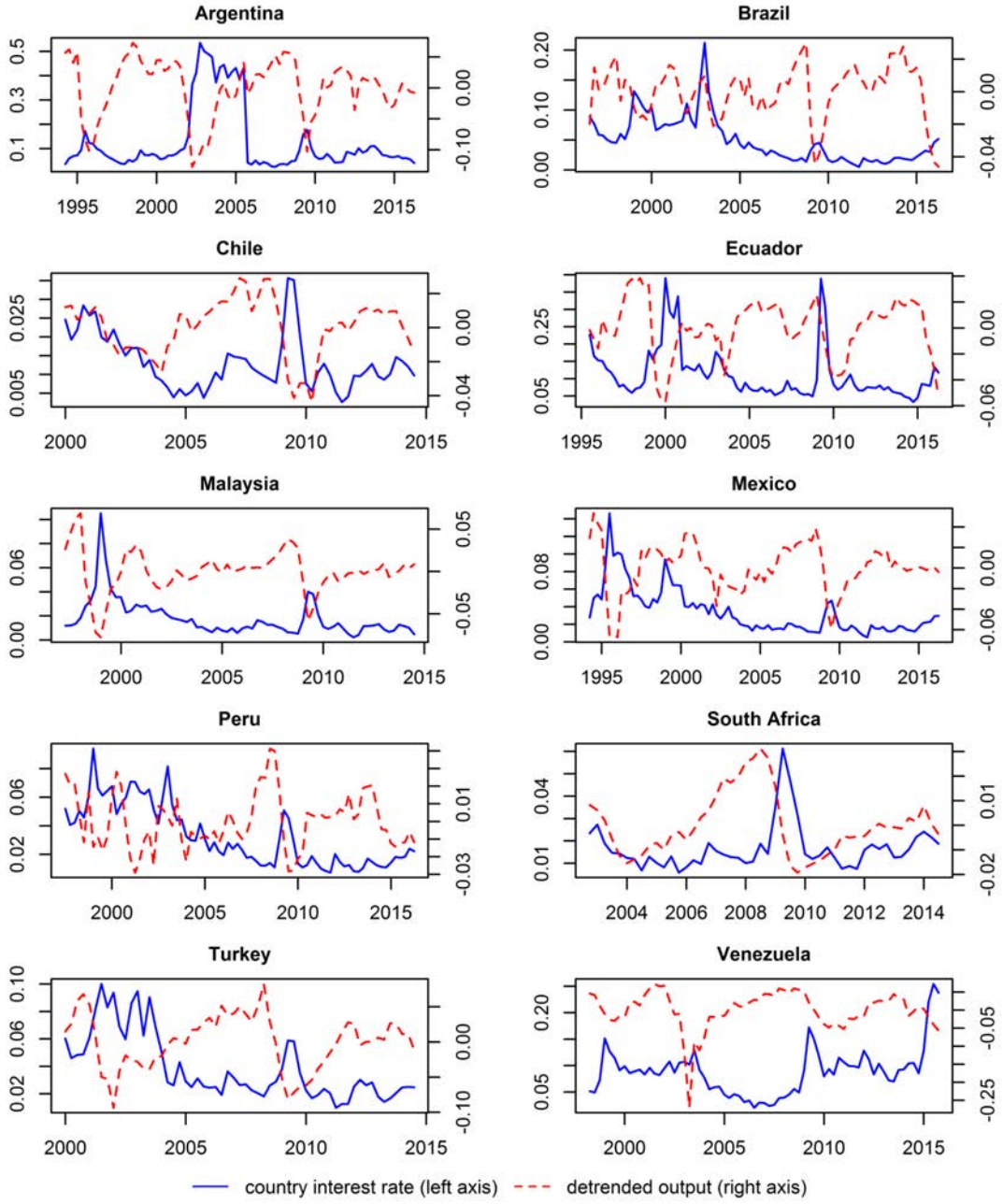


Notes: The U.S. real interest rate is measured by the three-month U.S. T-bill rate deflated by the average of U.S. CPI inflation in the current and previous three quarters. Country spreads are measured by the J.P. Morgan EMBI+ spreads. Rates are annualized and based on quarterly frequency from 1996Q1-2015Q4.

terest rate and output in Argentina, Brazil, Chile, Ecuador, Malaysia, Mexico, Philippines, South Africa, Turkey, and Venezuela are -0.54, -0.29, -0.26, -0.48, -0.65, -0.39, -0.32, -0.05, -0.53, and -0.28, respectively.[20] Lastly, Figure 4 presents the correlations of output and country interest at different lags (i. e. $corr(R_{t+h}, y_t)$ for $h = -4, -3, ..., 3, 4$ with h denoting one quarter) to shed some light on the leading or lagging behavior of interest rates in the two country groups. Despite the fact that there is some variability in the pattern of interest rates withing each group of countries, on average, it can be seen that interest rates in EC tend to lead the cycle by about one quarter while the interest rates in DC seem to lag the cycle by about two quarters. More specifically, the cross-correlogram for EC displays on

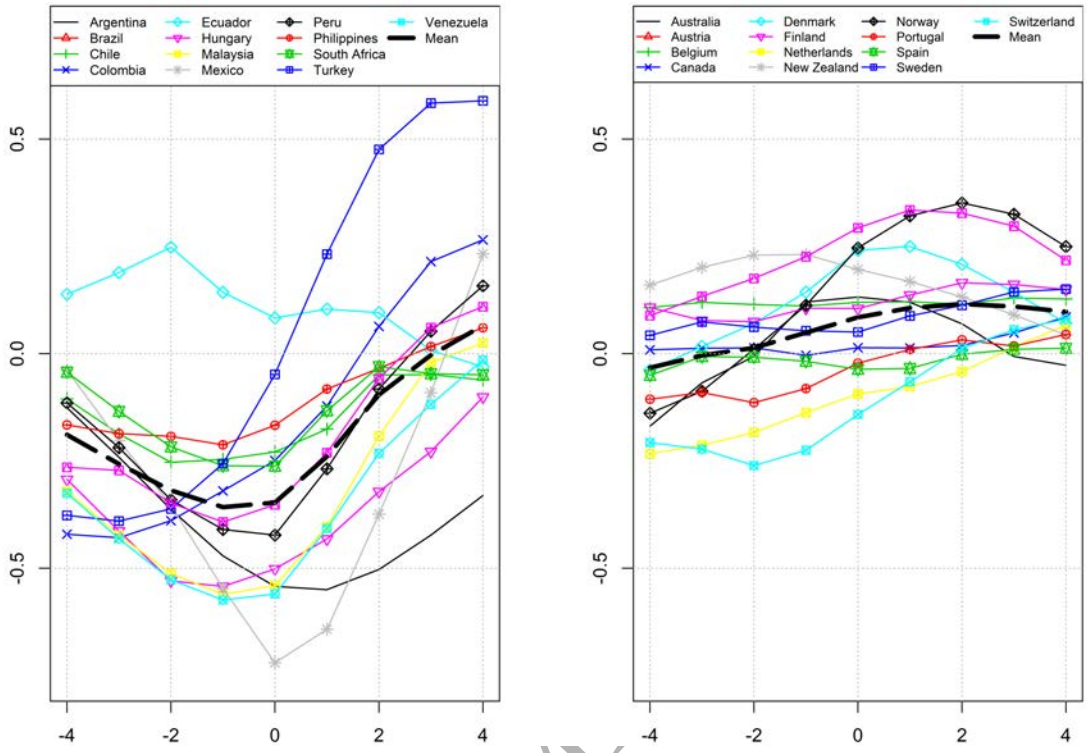
[20] See Table 3 for more details.

Figure 3: Comovement of Detrended Output and Country Interest Rates



average a U-shaped pattern and reaches the trough at $h = -1$. For DC the cross-correlation pattern is slightly hump-shaped and peaks at $h = 2$. This finding complements the evidence presented by Neumeyer and Perri (2005) who document similar results for a smaller and shorter sample of EC and DC.

Figure 4: Cross-Correlogram of Detrended Output and Country Interest Rate



Notes: The figure shows the correlation of detrended output and country interest rate at different lags i.e. $corr(R_{t+h}, y_t)$ for $h = -4, -3, ..., 3, 4$ where h denotes one quarter.

3 The Theoretical Model

Motivated by the evidence that EC exhibit large informal economies and volatile interest rates that lead the cycle and comove negatively with the cycle, this paper incorporates these features into a small open economy model to quantify their contribution to the pattern of business cycles in these countries. The framework builds on the work of Neumeyer and Perri (2005) and Restrepo-Echavarria (2014). It consists of a two-sector real business cycle model of a small open economy with an informal sector and a formal sector facing working capital. There is a representative household that supplies labor to both sectors. The formal labor income, in contrast to the informal labor income, is taxed since this activity is registered by the government. Government's revenue is used for unproductive activities. The size of the informal sector is given and is determined by the household's share of total time spent

working in the informal sector. The source of uncertainty are exogenous fluctuations in the country spread and sector-specific productivity.

3.1 Formal Sector

Perfectly competitive formal firms are registered by the government. As a result, formal firms have access to international markets. I assume that due to a friction in technology firms need to borrow a fraction of their labor inputs $\eta w_t^f n_t^f$ at the international interest rate R_t at the beginning of the period. Given the formal wage rate w_t^f, rental return on formal capital u_t^f, and R_t, firms utilize formal labor n_t^f and formal capital k_t^f to maximize their profits given by

$$\underset{\{k_t^f, n_t^f\}}{max} \quad y_t^f - u_t^f k_t^f - (1 + \eta R_t) w_t^f n_t^f \tag{1}$$

subject to the Cobb-Douglas production technology

$$y_t^f = z_t^f (k_t^f)^{\alpha_f} (n_t^f)^{1-\alpha_f}. \tag{2}$$

α_f is the capital's share of formal output y_t^f and z_t^f captures the sector-specific productivity. $\eta R_t w_t^f n_t^f$ represents the fraction of the formal wage bill paid in advance. Therefore, $\eta = 1$ means that firms pay their wage bill in full. The formal productivity is assumed to follow a standard AR(1) process

$$log(z_t^f) = \rho_{zf}\, log(z_{t-1}^f) + \epsilon_t^{zf} \tag{3}$$

where $\rho_{zf} \in (0, 1)$ governs the persistence of z_t^f and ϵ_t^{zf} is normally distributed with mean zero and time-invariant variance σ_{zf}^2.

3.2 Informal Sector

Informal firms are, by their nature, unregistered by the government and therefore do not have access to international markets. In line with most of the informal economy literature, I impose that the only factor of informal production is informal labor implying that the informal sector is labor intensive.[21] Furthermore, informal firms are assumed to face decreasing returns to scale governed by the parameter α_i. By choosing the level of informal labor n_t^i, informal firms maximize their profits given by

$$\underset{\{n_t^i\}}{max} \;\; p_t y_t^i - w_t^i n_t^i \tag{4}$$

subject to the decreasing returns to scale technology

$$y_t^i = z_t^i (n_t^i)^{\alpha_i}. \tag{5}$$

p_t reflects the relative price of informal to formal goods. Informal sector firms take the informal wage rate w_t^i and p_t as given. α_i determines the degree of decreasing returns and z_t^i denotes the level of informal productivity that follows an AR(1) process of the form

$$log(z_t^i) = \rho_{zi}\, log(z_{t-1}^i) + \epsilon_t^{zi} \tag{6}$$

where $\rho_{zi} \in (0, 1)$ is the persistence of z_t^i and ϵ_t^{zi} follows normal distribution with mean zero and variance σ_{zi}^2. Note that informal firms do not face a working capital constraint. The reason is that only formal firms are registered by the government and therefore only formal firms have access to international markets where they can borrow at R_t.

Although informal firms cannot borrow internationally, they might borrow from other types of borrowers, perhaps at a higher interest rate. I abstract from this possibility for three reasons. First, the interest rate at which informal firms might borrow should mostly

[21] See for example Restrepo-Echavarria (2014).

depend on firm-specific characteristics whereas R_t is mostly affected by global factors as documented by Longstaff et al. (2011). Thus, fluctuations in the international rate should leave borrowing of informal firms largely unaffected. Second, informal firms may not be able to borrow due to their nature of informality. La Porta and Schleifer (2014) illustrate that around 44 percent of all informal entrepreneurs surveyed (compared to only 18 percent of formal entrepreneurs) report that access to credit is the largest obstacle to doing business. For comparison, the second largest obstacle to doing business, reported by only 11.2 percent of informal entrepreneurs, is political instability. Last possible reason is that if the size of the wage bill paid in advance decreases with the size of the wage bill relative to firm's size then the fraction of the wage bill paid in advance by informal firms will be negligible. This is because of the fact that informal firms tend to be small - a well-known fact in the literature. With the use of Brazilian data Ulyssea (2015) shows that the likelihood of a firm being informal decreases with its size. Leal Ordonez (2014) documents that in Mexico 67 percent of all informal workers belongs to the establishments that are of smallest size (2-5 workers per establishment). This number increases to 89.1 percent when considering establishments that employ under 20 workers. Similarly, Bernabe (2016) reports that 82% of the micro and small enterprises in Egypt are informal.

3.3 Representative Household

Both formal and informal firms are owned by a representative household. The household chooses formal consumption c_t^f, informal consumption c_t^i, supply of formal labor h_t^f, supply of informal labor h_t^i, formal capital k_t^f, and amount of debt d_{t+1} to maximize its expected lifetime utility

$$\underset{\{c_t^f, h_t^f, c_t^i, h_t^i, k_{t+1}^f, d_{t+1}\}}{max} E_0 \sum_{t=0}^{\infty} \beta^t U(c_t^f, h_t^f, c_t^i, h_t^i) \tag{7}$$

subject to the following budget constraint

$$p_t c_t^i + c_t^f + i_t^f + (1 + R_t)d_t + \Psi(d_{t+1}) \leq u_t^f k_t^f + w_t^i h_t^i + (1 - \tau) w_t^f h_t^f + d_{t+1}\,, \tag{8}$$

the law of motion of formal capital stock

$$i_t^f = k_{t+1}^f - (1-\delta)k_t^f + \Phi(k_{t+1}^f, k_t^f)\,, \tag{9}$$

and the standard non-Ponzi scheme condition

$$\lim_{j\to\infty} E_t[\Pi_{s=0}^{j}(1+R_{t+s})]^{-1} d_{t+j} \leq 0. \tag{10}$$

i_t^f denotes formal investment, d_t denotes households debt position in period t, and $\delta \in (0,1)$ represents the depreciation of formal capital.

Equation (6) states that the household uses its income obtained by working in both sectors, renting capital in formal sector, and borrowing in the international markets on formal consumption, informal consumption, formal investment, and to pay off its debt from last period. The accumulation of formal capital is subject to capital adjustment costs, defined by $\Phi(k_{t+1}^f, k_t^f)$, where the function $\Phi(.)$ is assumed to be strictly increasing and convex. Moreover, $\Phi(\bar{k}^f) = \Phi'(\bar{k}^f) = 0$ to ensure that there are no adjustment costs in the steady state. The reason for having formal capital adjustment costs is that only the formal firms have access to international markets and therefore only formal investment goods can be traded across borders.[22] The assumption of capital adjustment costs is standard in the small open economy literature to reduce the counter-factually high investment volatility. Furthermore, it emphasizes the fact that it is more difficult to transfer physical capital across countries than financial assets.

I also introduce the debt adjustment costs $\Psi(d_{t+1})$, where $\Psi(\bar{d}) = \Psi'(\bar{d}) = 0$ for some $\bar{d} > 0$, to eliminate the well-known unit-root of debt holdings in small open economy models. Schmitt-Grohe and Uribe (2003) discuss several ways of inducing stationarity in a small open economy framework and conclude that all of them produce essentially identical results

[22] This can be seen in Section 3.6 in equations (16)-(18).

for business cycle fluctuations in a small open economy setting.[23] Uribe and Yue (2006) demonstrate that the debt adjustment costs can be microfounded as having competitive banks borrow funds from the foreign investors at the international rate R_{t+1} and lend to domestic agents at the domestic rate R^d_{t+1}. Moreover, banks incur operational costs in terms of $\Psi(d_{t+1})$ specified as above, choose the amount of d_{t+1} to maximize their profits given by $R^d_{t+1}[d_{t+1} - \Psi(d_{t+1})] - R_{t+1}d_{t+1}$ and distribute the profits back to the household in a lump-sum fashion. The first-order condition then implies $R^d_{t+1} = R_{t+1}/[1 - \Psi'(d_{t+1})]$, which is exactly the shadow interest rate faced by the representative household.

3.4 Government

The government obtains its revenue by levying a time-invariant tax on the household's formal labor income and uses the revenue for non-productive activities. The government's budget constraint given by

$$g_t = \tau w^f_t h^f_t \tag{11}$$

holds every period. The informal labor activities are not registered by the government, so this labor income is not taxed.

3.5 Interest Rates

The interest rate faced by an emerging country R_t is a product of a world interest rate R^{US}_t and country risk component S_t,

$$R_t = R^{US} S_t. \tag{12}$$

Following Uribe and Yue (2006), R^{US} is proxied by the 3-month U.S. Treasury bill rate and is assumed to be constant as in the related literature.[24] The country spread is measured

[23] With debt adjustment costs, formal consumption would be measured as $c^f_t + \Psi(d_t)$ in reality, and not just as c^f_t. However, these two measures are identical up to first order due to the assumption that $\Psi'(\bar{d}) = 0$.

[24] See for example Schmitt-Grohe and Uribe (2003). Another reason for this assumption is the fact that the standard deviation of R^{US} is negligible. In particular, the standard deviation of R^{US} is about 0.005, whereas the standard deviation of S is about 0.14 in Argentina and 0.03 in Mexico for the identical period

using the J.P. Morgan EMBI+ data over the period 1994:Q1 - 2015:Q4 and is assumed to follow a standard AR(1) process

$$log(S_t) = \rho_S \, log(S_{t-1}) + \epsilon_t^S \tag{13}$$

where $\rho_S \in (0, 1)$ governs the persistence of S_t and ϵ_t^S follows a normal distribution with mean zero and variance σ_S^2. Given the decomposition of the interest rate, a shock to country spread may be interpreted as a shock to country interest rate.

Several papers assume that the probability of country's default on its sovereign debt depends on domestic fundamentals. Arellano (2008) endogenizes country's probability of default and interest rate and shows that the model is successful at matching key characteristics of Argentine business cycles. Lopez-Martin et al. (2017) consider a small open economy model with sovereign default, endogenous fiscal policy and stochastic commodity revenues to analyze how changes in commodity prices impact government's budget and its ability to borrow internationally. In their case, the probability of country's default depends on domestic productivity and world commodity prices.

In contrast, this paper assumes that debt held by domestic agents is paid off in every period, but there is a chance of potential default on payments to foreign investors. Changes in this probability of default create fluctuations in the country spread. This assumption is in line with the work of Neumeyer and Perri (2005) and Fernandez-Villaverde et al. (2011). It is motivated by the empirical evidence of Uribe and Yue (2006) and Longstaff et al. (2011), who show that country spreads are mostly driven by factors exogenous to emerging country's local conditions. In addition, Akinci (2013) finds that global financial factors and country spreads account for more than a third of business cycle fluctuations in EC. More importantly, Akinci reports that most of the extent to which global factors affect domestic economic variables is through their impact on country spreads. However, I do not mean to downplay the importance of allowing for a sovereign default. Examining the importance of

from 1994:Q1 - 2015Q4.

sovereign default in the presence of informal sector would be a useful extension for future research.

3.6 Equilibrium

Given the initial conditions $z_0^f, z_0^i, S_0, d_0, k_0^f$ and the exogenous processes $\{z_t^f, z_t^i, S_t, \epsilon_t^S, \epsilon_t^{zf}, \epsilon_t^{zi}\}$, a competitive equilibrium is a set of quantities $\{y_t^j, c_t^j, n_t^j, h_t^j, i_t^f, k_{t+1}^f, d_{t+1}, g_t, tb_t\}_{j=f,i}$ and prices $\{u_t^f, w_t^j, R_t\}_{j=f,i}$ satisfying (1) - (13) such that given prices (i) the formal firms' decision rules solve formal firms' problem, (ii) the informal firms' decision rules solve the informal firms' problem, (iii) the household's decisions rules solve household's problem, and (iv) markets clear in every period:

$$h_t^f = n_t^f, \tag{14}$$

$$h_t^i = n_t^i, \tag{15}$$

$$y_t^f = c_t^f + i_t^f + g_t + tb_t, \tag{16}$$

$$(1 + R_t)d_t + \Psi(d_{t+1}) = d_{t+1} + tb_t, \tag{17}$$

$$y_t^i = c_t^i. \tag{18}$$

The fact that formal firms are registered by the government, but informal firms are not, implies through (14) and (16) that formal output can be used to cover formal consumption, formal investment, government expenditures, and trade balance. On the other hand, informal output can be just used on informal consumption. This is in line with the empirical evidence of Gasparini and Tornarolli (2009), who show that non-tradable sectors in Latin and Caribbean countries consist mostly of informal labor force.

4 Functional Forms and Calibration

The goal of this section is to introduce functional forms of the adjustment costs and utility functions and to present the values of calibrated parameters for two emerging countries: Argentina and Mexico. I adopt the following standard functional forms for debt holding costs, $\Psi(d_{t+1}) = \frac{\psi}{2}(d_{t+1} - \bar{d})^2$, and formal capital adjustment costs, $\Phi(k^f_{t+1}, k^f_t) = \frac{\phi}{2}(k^f_{t+1} - k^f_t)^2$. These functional forms imply absence of adjustment costs in the steady state. The utility function is assumed to take the standard Cobb-Douglas form as in Benhabib et al. (1991),

$$U(c^f_t, h^f_t, c^i_t, h^i_t) = \frac{\left\{\left[a(c^f_t)^e + (1-a)(c^i_t)^e\right]^{b/e}(1 - h^f_t - h^i_t)^{1-b}\right\}^{1-\gamma}}{1-\gamma} \tag{19}$$

with $h^i_t + h^f_t \leq 1$ for all t and γ and b being the utility curvature and consumption share parameters, respectively. Benhabib et al. (1991) consider home and market consumption and hours worked whereas I focus on formal versus informal consumption and hours worked. Restrepo-Echavarria (2014) uses a similar utility functional form with the difference that the consumption goods are assumed to be perfect substitutes and that the household does not value leisure.

$1/(1-e)$ denotes the elasticity of substitution between formal and informal consumption. High substitutability of formal and informal consumption seems plausible as almost the same quality of clothes, fruit, and vegetables sold by a street vendor is provided by a grocery store or a supermarket. Restrepo-Echavarria (2014) also adds that many EC have a special type of electronic malls that are usually located in low-income neighborhoods and sell the same goods as official stores such as Apple or Sony, but at lower prices, since these malls frequently avoid paying taxes on their electronic products. This implies that the substitutability between formal and informal goods is potentially higher than the one between market and home production. For this reason, Restrepo-Echavarria (2014) assumes that formal and informal consumption goods are perfect substitutes. On the other hand, Benhabib et al. (1991) assume an elasticity of five, since they consider substitutability between market and non-

Table 4: Calibration

Symbol	Description	Argentina	Mexico
β	subjective discount factor	0.99	0.99
γ	utility curvature	5	5
α_f	formal capital share	0.4	0.35
α_i	degree of decreasing returns in informal sector	0.3	0.3
δ	depreciation of formal capital	0.74%	1.33%
d/y^f	steady-state level of debt to formal output	0.1	0.1
τ	formal labor tax rate	0.32	0.11
η	working capital	0.5	0.5
ϕ	formal capital adjustment costs	1.8	0.6
ψ	portfolio adjustment costs	0.3	0.3
$1/(1-e)$	elasticity of substitution	8	8
$h^f + h^i$	total hours worked	0.27	0.38
h^i	sets size of informal sector	0.07	0.11
a, b	set hours worked in formal and informal sector	0.41, 0.44	0.37, 0.54
ρ_{zf}	persistence of formal technology process	0.95	0.95
σ_{zf}	variability of formal technology process	0.68%	0.53%
ρ_{zi}	persistence of informal technology process	0.95	0.95
σ_{zi}	variability of informal technology process	4.3%	2.2%
ρ_S	persistence of country spread process	0.96	0.96
σ_S	variability of country spread process	5.5%	1.2%

market activities. As a result, I choose the benchmark value of the elasticity of substitution between formal and informal goods to be 8 (for both countries), which is in-between the home production value and the value of Restrepo-Echavarria and lines up with the value reported in Fernandez and Meza (2015). I experiment with alternative values in the sensitivity analysis. Notice that (19) implies that the labor flows freely between sectors. This is in line with the findings of Maloney (1999) and Pratap and Quintin (2006), who reject the hypothesis of a significant fragmentation of labor market between formal and informal sectors in Argentina and Mexico. Amaral and Quintin (2006) also assume that labor is free to flow between the two sectors in their theoretical model.

The time period in the model is a quarter. Baseline parameter values are chosen to match the features of business cycles in Argentina and Mexico over the 1994Q1 - 2015Q4 period. Table 4 provides the description and values of the parameters considered in the

analysis. Values of the following parameters are assumed to be identical for both countries. I choose β to obtain a four percent annual real interest rate. The steady state level of debt to formal output ratio, d/y^f, is set to 10 percent as in Aguiar and Gopinath (2007) and in Fernandez and Meza (2015). The curvature of the utility function or the inverse of intertemporal elasticity of substitution, γ, is set to 5 to be in line with Neumeyer and Perri (2005) and Fernandez-Villaverde (2011). Empirical evidence on the value of the working capital, especially in EC, is fairly limited. For a large sample of U.S. companies over the period 1982-2011, Aktas et al. (2015) document the working capital to sales ratio of about 0.2. Chan (2014) adds that firms in developing countries tend to be more financially constrained and tend to exhibit a relatively higher working capital as capital in these countries is more scarce. Chan reports that firms in Bangladesh in 2002 retained about 35 percent of their sales as working capital. de Almeida and Eid Jr. (2014) show that publicly traded Brazilian firms between 1995-2009 displayed a working capital to market value ratio of about 0.27. This value underestimates the working capital-sales ratio, if a firm's market value is higher than its sales. Using a large sample of Chinese firms between 2000-2007, Ding et al. (2013) observe a working capital to sales ratio of about 0.47. On the theoretical side, Neumeyer and Perri (2005) assume that firms pay fully their wage bill in advance ($\eta = 1$) to generate significant countercyclicality in interest rates. Uribe and Yue (2006) use $\eta = 1.2$, because they find that it minimizes the distance between their estimated and model implied impulse response functions. For this reason, I choose η to be 0.5 under the benchmark model and I experiment with alternative values in the sensitivity section. I follow Restrepo-Echavarria (2014) to fix the degree of decreasing returns to scale in the informal sector, α_i, to 0.3. The value of the portfolio adjustment costs, ψ, is chosen to be closely in line with the estimated value of Garcia-Cicco et al. (2010) and with the value used by Jahan-Parvar et al. (2013) for Argentina in their benchmark specification.

Following Neumeyer and Perri (2005), I choose α_f to target Argentine formal labor share of 0.6. For Mexico the formal capital share is set to 0.35 following Fernandez and Meza (2015)

who cite empirical evidence reported in Garcia-Verdu (2005). The depreciation of capital, δ, is chosen such that it generates an investment-to-output ratio of 0.17 and 0.2 in Argentina and Mexico, respectively. The tax rate on formal labor income is set to 0.32 in Argentina as documented in Aruoba (2010) and presented in Restrepo-Echavarria (2014). The tax rate on formal wage bill in Mexico equals about 0.11 following Fernandez and Meza (2015) who estimate it empirically applying methodology by Mendoza et al. (1994) on Mexican data. The degree of formal capital adjustment costs, ϕ, targets the observed investment volatility. The values of a and b are calibrated such that the model matches an average time spent working of total time of 0.27 in Argentina over the 2003Q1 - 2015Q3 period and such that the household spends 25.3 percent of this time working in the informal sector.[25] In other words, $h^f + h^i = 0.27$ in the steady state. For Mexico, total hours worked equals to 0.38 based on the online Appendix of Fernandez and Meza (2015) and the size of Mexican informality is set to 30 percent following the evidence in Schneider et al. (2010).

The values for persistence and volatility of formal productivity shock are taken from Garcia-Cicco et al. (2010) for Argentina and from Aguiar and Gopinath (2007) for Mexico, who estimate these values using data for the corresponding countries. Due to the lack of data availability on the informal sector, the persistence of informal productivity shocks is set to equal to its formal counterparts and the standard deviations are pinned down such that the model replicates the observed volatility of output in both countries. Consequently, the productivity shock is more volatile in the informal sector than in the formal sector for both countries. Last parameter pertaining to the productivity processes is the correlation between the productivity shocks, $\rho_{zizf} = corr(\epsilon^{zi}, \epsilon^{zf})$.[26] Similarly to Fernandez-Villaverde (2011) to better isolate the effects of individual shocks, I assume that the two productivity shocks are independent from each other ($\rho_{zizf} = 0$) for the benchmark model and consider

[25] I source the hours worked data for Argentina from Informe Economico. The size of the informal economy is the average size of the informal economy in Argentina calculated by Schneider et al. (2010) using the MIMIC approach over the years 1999 - 2007 and reported in Figure 1 above.

[26] Note that I do not have to worry about the correlation between a sector-specific productivity shock and a country spread shock, since shocks to country spread are exogenous and therefore do not depend on local economic conditions.

alternative correlation values in the sensitivity analysis. I estimate the persistence and standard deviation of the country spread process in (13) using the J. P. Morgan EMBI+ data over the 1994:Q1 - 2015:Q4 sample. The estimated value of country spread process volatility for Argentina is higher than the one for Mexico reflecting the Argentine sovereign default and is also slightly higher than the one obtained by Neumeyer and Perri (2005), since my sample contains the recent financial crisis. I follow closely Schmitt-Grohe and Uribe (2004) and solve the model by log-linearizing it around the steady state.

5 Findings

First, this section compares empirical and model-implied moments for Argentina and Mexico. Second, it displays the impulse response functions of economic quantities to technology and country spread shocks. Lastly, the section provides sensitivity analysis for selected model parameters.

5.1 Moments

After solving the calibrated model, I compute the business cycle moments for Argentine and Mexican economies. To be consistent with Restrepo-Echavarria (2014) and Fernandez and Meza (2015), I consider an extreme situation in which none of the informal economy is captured in country's national accounts as the baseline model and also report results for a case in which a half of the informal economy is measured. Fernandez and Meza (2015) construct their own measures of informal employment and find that Instituto Nacional de Estadistica y Geografia (INEGI), the statistical agency in Mexico, includes on average about a half of the informal labor in country's national accounts. I consider the extent to which mismeasurement of the informal sector affects the results in the sensitivity analysis. In addition, I consider a version of the model with interest rate shocks being the only source of uncertainty in order to isolate the role of interest rates on business cycle fluctuations in EC.

In all models, the value of capital adjustment costs parameter, ϕ, is calibrated such that the model matches the relative volatility of investment to output in the data.[27]

Under the baseline specification, the reported moments are for the case when none of the informal economy is captured in national accounts and therefore refer to the moments of formal sector economic quantities. As mentioned before, many EC exhibit large informal economy, but are usually reluctant to devote sufficient financial resources to appropriately capture the size of their informal economy in their national accounts. In the other case similar to Fernandez and Meza (2015), when a fraction θ of the informal economy is captured in national accounts, the reported moments correspond to total quantities. More specifically, total consumption, c^T, is measured as the sum of formal and informal consumption, $c_t^T = c_t^f + \theta p_t c_t^i$, total output, y^T, is defined as the sum of formal and informal output, $y_t^T = y_t^f + \theta p_t y_t^i$, and total trade balance is calculated as $tb_t^T = y_t^T - c_t^T - i_t^f - g_t$. Investment remains unchanged as only the formal sector uses investment goods for production. Consequently, in Table 5 $\theta = 0$ denotes a scenario when the informal sector is completely mismeasured and $\theta = 0.5$ indicates a scenario when a half of the size of the informal sector is included in country's national accounts.

Table 5 compares the empirical and model-implied business cycle moments for Argentina and Mexico. For the baseline case with $\theta = 0$ and all three shocks included, the model generates more volatile consumption than output in both countries and more than two (three) times more volatile investment than output in Argentina (Mexico). The model, however, understates the relative volatility of trade balance-to-output ratio and the pro-cyclicality of investment. However, the cyclicality of investment improves with the measurement of the informal sector. Table 5 shows that although the countercyclicality of interest rate is too low, the model matches well the countercyclicality of the trade balance-to-output ratio. Lastly, the model produces a relatively low correlation between the trade balance-to-output ratio and interest rate.

[27] See Table 5 for more details.

Table 5: Business Cycles in Argentina and Mexico: Data vs. Model

Argentina	Data	Baseline $\theta = 0$	Baseline $\theta = 0.5$	R shocks only $\theta = 0$	R shocks only $\theta = 0.5$
$\sigma(y)$	4.76	4.75	3.19	0.76	0.63
$\sigma(c)/\sigma(y)$	1.27	1.47	1.05	1.06	1.05
$\sigma(i)/\sigma(y)$	2.39	2.38	2.39	2.41	2.38
$\sigma(tb/y)/\sigma(y)$	0.94	0.03	0.05	0.83	0.76
$\rho(c, y)$	0.95	0.90	0.94	0.84	0.80
$\rho(i, y)$	0.89	-0.07	0.30	0.43	0.44
$\rho(tb/y, y)$	-0.48	-0.50	-0.02	-0.21	0.11
$\rho(R, y)$	-0.54	-0.02	-0.02	-0.96	-0.96
$\rho(c, R)$	-0.54	-0.01	-0.02	-0.82	-0.80
$\rho(i, R)$	-0.49	-0.01	-0.01	-0.47	-0.50
$\rho(tb/y, R)$	0.75	0.11	-0.01	-0.04	-0.03
Mexico					
$\sigma(y)$	2.20	2.23	1.17	0.21	0.18
$\sigma(c)/\sigma(y)$	1.22	1.40	1.10	1.12	1.11
$\sigma(i)/\sigma(y)$	3.19	3.20	3.20	3.23	3.21
$\sigma(tb/y)/\sigma(y)$	0.71	0.02	0.13	0.95	0.93
$\rho(c, y)$	0.89	0.78	0.86	0.91	0.87
$\rho(i, y)$	0.86	0.21	0.47	0.40	0.43
$\rho(tb/y, y)$	-0.51	-0.32	-0.16	-0.15	-0.07
$\rho(R, y)$	-0.39	-0.01	0.02	-0.96	-0.95
$\rho(c, R)$	-0.48	-0.01	0.00	-0.86	-0.84
$\rho(i, R)$	-0.34	-0.01	0.00	-0.41	-0.46
$\rho(tb/y, R)$	0.52	0.03	0.00	0.16	-0.07

Notes: Baseline refers to the benchmark model in which the informal sector is mismeasured completely ($\theta = 0$) or under which a half of the informal sector is captured in national accounts ($\theta = 0.5$). R shocks only denotes a model version with only interest rate shocks. In the four considered models ϕ is set to 1.8, 3.6, 1.6, 2.2 for Argentina and to 0.6, 0.8, 1.0, 1.6 for Mexico.

When assuming that a half of the informal economic activity is registered ($\theta = 0.5$), the model still generates a relatively higher volatility of consumption to output, even though the volatility of output decreases slightly. In addition, the generated correlation of output and investment is now closer the one observed in the data, while the correlation between trade balance-to-output ratio and output becomes less negative. Considering interest rate shocks as the only source of uncertainty substantially decreases the volatility of output for both countries. In particular, the contribution of interest rates to business cycle fluctuations is

about 16 and 10 percent for Argentina and Mexico, respectively. This is consistent with the empirical evidence of Akinci (2013) who reports that country spread shocks explain about 15% of changes in macroeconomic activity in EC. More importantly, the relative volatilities of consumption and investment remain close to their empirical counterparts and the model now generates strongly countercyclical interest rates and procyclical investment.

5.2 Impulse Response Functions

Figures 4 and 5 present the impulse response functions for Argentina and Mexico. The three columns show, respectively, the impulse responses of economic quantities to a one standard deviation increase in country spread, informal productivity, and formal productivity. Figures 4 and 5 demonstrate that an increase in country's interest rate causes, in both countries, a decrease in formal output, consumption, investment, hours, and an improvement in trade balance-to-output ratio since savings increase and investment falls. On the other hand, a raised interest rate leads to an increase in informal output, consumption, and hours worked. Since only the formal sector is measured, an interest rate shock triggers an economic contraction. The pattern of the informal sector is in line with empirical evidence of Fernandez and Meza (2015), who show that the informal sector tends to be countercyclical. Note that the countercyclical feature of the informal sector prevails under all three shocks.

It can be seen from Figures 4 and 5 that when a country experiences an improvement in the informal technology, z^i, agents allocate more hours worked (at the expense of working less in the formal sector) and investment to the informal sector to increase informal production and consumption, since now the informal sector is relatively more productive. In addition, as agents substitute from formal to informal consumption, both formal output and consumption decrease. The trade balance-to-output ratio decreases because of the substantial decrease in formal output. An increase in formal productivity, z^f, implies an increase in formal labor and investment. This allows agents to increase formal output and consequently their formal consumption. Because of the high substitutability between formal and informal consumption

goods, informal output, hours worked, consumption all decrease in this case. The trade balance-to-output ratio decreases as investment increases, savings falls, and formal output improves before reverting back to the steady state levels.[28]

The intuition behind the responses of economic quantities to the country spread shock is similar to the one in Neumeyer and Perri (2005) and hinges on the behavior of the formal and informal labor markets. The equilibrium of the labor market in the formal sector is represented by the following equation

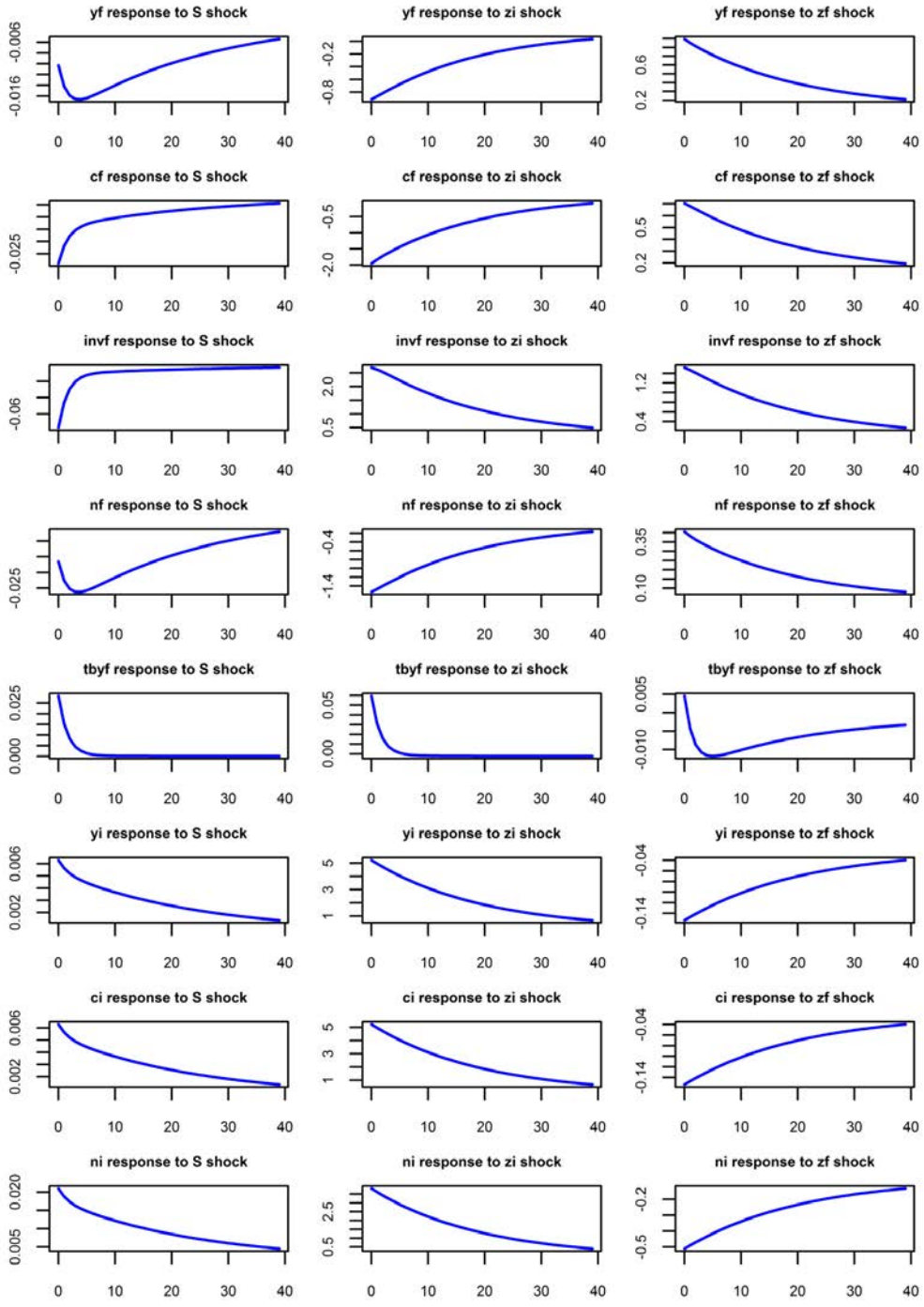
$$-\frac{U_{h^f}(c_t^f, h_t^f, c_t^i, h_t^i)}{U_{c^f}(c_t^f, h_t^f, c_t^i, h_t^i)} = w_t^f = \frac{(1-\alpha_f)y_t^f}{(1+\eta R_t)n_t^f}, \tag{20}$$

which equates the marginal rate of substitution between formal consumption and formal labor (labor supply) on the left-hand side and the marginal product of formal labor (labor demand) on the right-hand side. Formal firms finance a fraction of their wage bill by borrowing at the international interest rate. This implies that the labor demand by formal firms is adversely affected by the amount of labor cost paid in advance. Thus, an increase in the interest rate decreases the demand for formal labor and shifts the formal labor demand to the left as the labor costs increase due to the working capital assumption. However, the formal labor supply increases with the interest rate, since it is negatively related to formal consumption because of the Cobb-Douglas utility specification. Moreover, an increased interest rate makes today's consumption more expensive relative to tomorrow's consumption. For this reason, on impact consumption decreases and agents increase (decrease) their labor supply and decrease (increase) their leisure in the current (next) period to be able to save more when the interest rate is high.

The resulting change in equilibrium hours worked depends on the relative magnitudes of the individual shifts of labor supply and labor demand. The current values of η and the relative size of the productivity and interest rate shocks result in the magnitude of the labor demand shift that exceeds the one of the labor supply. In particular, the calibrated

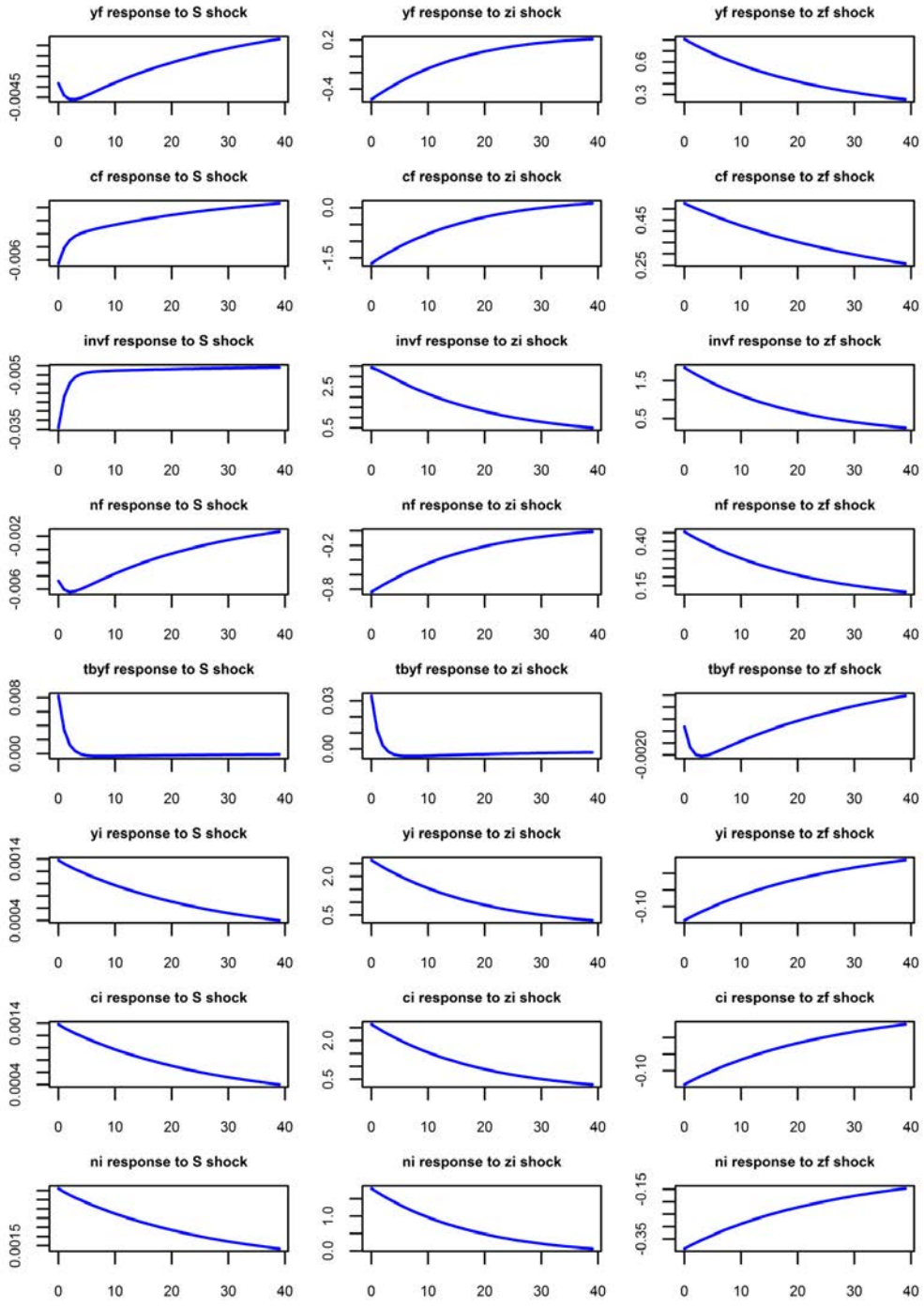
[28] See Mendoza (1991) for more details.

Figure 5: Impulse Response Functions: Argentina



Notes: yf, cf, invf, nf, tbyf, yi, ci, ni denote formal output, formal consumption, formal investment, formal hours worked, trade balance relative to formal output, informal output, informal consumption, and informal hours worked. The three columns show impulse responses to a one standard deviation increase in country spread (S), informal productivity (zi), and formal productivity (zf), respectively.

Figure 6: Impulse Response Functions: Mexico



Notes: yf, cf, invf, nf, tbyf, yi, ci, ni denote formal output, formal consumption, formal investment, formal hours worked, trade balance relative to formal output, informal output, informal consumption, and informal hours worked. The three columns show impulse responses to a one standard deviation increase in country spread (S), informal productivity (zi), and formal productivity (zf), respectively.

model parameters and the fact that household allocates its time to working in both sectors imply that formal employment decreases, which causes a decrease in formal output and consequently yields countercyclical trade balance-to-output ratio and countercyclical interest rates when the country spread shock hits.

To understand the decrease in formal employment further, it is useful to also analyze the equilibrium of the labor market in the informal sector, which is given by

$$-\frac{U_{h^i}(c_t^f, h_t^f, c_t^i, h_t^i)}{U_{c^i}(c_t^f, h_t^f, c_t^i, h_t^i)} = w_t^i = \frac{\alpha_i y_t^i}{n_t^i}. \tag{21}$$

(21) states that the equilibrium wage rate equates the marginal rate of substitution between informal consumption and informal labor and the marginal product of informal labor. Unlike formal firms, informal firms are not directly affected by an interest rate shock since they do not face a working capital constraint. As a result, when the interest rate increases, the formal firms are more negatively affected than informal firms and the household correspondingly increases its hours worked in the informal sector and decreases its hours worked in the formal sector.

The presence of a larger relative volatility of formal consumption to output is mainly due to the substitutability between formal and informal consumption and the fact that a large fraction of the informal sector remains unregistered. Since only formal firms are registered by the government and hence only formal consumption is traded internationally, interest rate shocks affect formal consumption disproportionally more than informal consumption through trade balance.[29] This is clear from equations (16) - (18), which state that $y_t^f = c_t^f + i_t^f + g_t + (1 + R_t)d_t + \Psi(d_{t+1}) - d_{t+1}$ where $tb_t = (1 + R_t)d_t + \Psi(d_{t+1}) - d_{t+1}$ and $y_t^i = c_t^i$. As a result, with raised interest rates, agents substitute from formal consumption to informal consumption and invest less in the formal sector. This implies that the trade balance improves and causes output to be less volatile than consumption, when only the formal sector is measured or when a large part of the informal sector is unmeasured. The

[29] Restrepo-Echavarria (2014) names this fact the so called strategic savings motive.

next subsection explains the fact that the relative volatility of consumption to output is actually less than one, when countries measure their informal sector relatively well.

5.3 Sensitivity Analysis

This section explores the robustness of the main findings. Table 6 contrasts the results of the benchmark specification with alternative values for the mismeasurement of the informal sector, θ, degree of decreasing returns to scale in the informal sector, α_i, amount of wage bill paid in advance by formal firms, η, correlation between the formal and informal productivity shocks, ρ_{zizf}, and the elasticity of substitution between formal and informal consumption goods, $1/(1-e)$. When one parameter changes, all other parameters are held fixed at their baseline values.

First, Table 6 depicts that changes in the degree of decreasing returns in the informal sector leave the key Argentine and Mexican moments relatively unaffected. Perhaps, the two most notable differences are that an increase in α_i slightly decreases the relative volatility of consumption to output and increases the relative volatility of investment to output. The intuition lies in the fact that an increase in α_i raises the value of the labor demand in the formal sector in (19). For this reason, when the shock hits, it is more profitable to increase informal hours worked and to decrease more substantially formal hours worked. A more significant decrease in formal hours worked results mostly in a higher volatility of formal output and hence in a lower relative volatility of formal consumption to formal output.

Second, it can be seen in Table 6 that variations in the value of η do not alter the main results much. The value of the wage bill paid in advance matters chiefly for the effects of country spread shocks on the interest rate countercyclicality through equation (20). A smaller value of the wage bill paid in advance results in a smaller shift of formal labor demand to the left and thus causes a lower volatility of formal hours worked. This lowers the volatility of formal output and raises the relative volatility of formal consumption and investment to formal output. The countercyclicality of trade balance-to-output ratio and

Table 6: Sensitivity Analysis

		α_i		η		$1/(1-e)$		ρ_{zizf}		θ	
Argentina	Benchmark	0.2	0.4	0.1	0.9	2	15	-0.5	0.5	0.1	0.9
$\sigma(y)$	4.75	5.34	4.55	4.80	4.70	3.52	5.08	6.33	4.28	4.43	3.31
$\sigma(c)/\sigma(y)$	1.47	1.60	1.37	1.49	1.44	1.25	1.48	1.39	1.29	1.40	0.76
$\sigma(i)/\sigma(y)$	2.38	2.86	2.05	2.49	2.28	3.04	2.25	1.50	3.60	2.55	3.41
$\sigma(tb/y)/\sigma(y)$	0.03	0.04	0.03	0.03	0.03	0.04	0.03	0.02	0.04	0.03	0.03
$\rho(c,y)$	0.90	0.88	0.92	0.89	0.91	0.79	0.91	0.98	0.71	0.89	0.97
$\rho(i,y)$	-0.07	-0.17	0.03	-0.05	-0.08	0.36	-0.13	-0.26	0.37	0.00	0.78
$\rho(tb/y,y)$	-0.50	-0.48	-0.51	-0.49	-0.50	-0.37	-0.52	-0.66	-0.37	-0.49	-0.05
$\rho(R,y)$	-0.02	-0.01	-0.02	0.00	-0.03	-0.02	-0.01	-0.01	-0.02	-0.02	-0.02
$\rho(c,R)$	-0.01	-0.01	-0.01	0.00	-0.02	-0.01	-0.01	-0.01	-0.01	-0.01	-0.02
$\rho(i,R)$	-0.01	-0.01	-0.01	0.00	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
$\rho(tb/y,R)$	0.11	0.08	0.13	0.10	0.12	0.13	0.10	0.12	0.09	-0.01	-0.05
Mexico											
$\sigma(y)$	2.23	2.82	2.03	2.26	2.20	1.47	2.47	3.32	3.43	2.06	1.30
$\sigma(c)/\sigma(y)$	1.40	1.50	1.32	1.40	1.40	1.09	1.44	1.43	1.10	1.34	0.82
$\sigma(i)/\sigma(y)$	3.20	3.78	2.75	3.22	3.18	3.57	3.09	1.32	3.68	3.33	4.10
$\sigma(tb/y)/\sigma(y)$	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
$\rho(c,y)$	0.78	0.73	0.83	0.78	0.79	0.66	0.81	0.97	0.62	0.77	0.80
$\rho(i,y)$	0.21	0.19	0.26	0.22	0.21	0.57	0.15	-0.29	0.65	0.26	0.70
$\rho(tb/y,y)$	-0.32	-0.32	-0.33	-0.32	-0.32	-0.24	-0.34	-0.39	0.64	-0.31	-0.13
$\rho(R,y)$	-0.01	0.00	-0.01	0.00	-0.01	-0.01	0.00	0.00	0.00	0.00	0.00
$\rho(c,R)$	-0.01	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	0.00
$\rho(i,R)$	-0.01	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	0.00
$\rho(tb/y,R)$	0.03	0.02	0.03	0.02	0.03	0.04	0.03	0.03	0.03	0.01	0.01

Notes: Benchmark refers to the model with sector-specific technology shocks, interest rate shocks, $\alpha_i = 0.3$, $\eta = 0.5$, $1/(1-e) = 8$, $\rho_{zizf} = 0$, and $\theta = 0$.

interest rate slightly decreases as formal firms are affected less by increases in interest rate when the amount of wage bill paid in advance decreases. The small effect is given by the fact that the countercyclicality of trade balance-to-output ratio and interest rate is predominantly determined by the relative size of technology shocks, since the technology shocks play a more important role in driving the business cycles than the interest rate shocks.

Third, Table 6 reports that changes in the elasticity of substitution between formal and informal consumption mostly affect relative volatility of consumption to output. The reason is that as the substitutability between consumption goods increases, agents are more willing

to substitute formal for informal consumption during periods of elevated interest rates or relative improvements in informal productivity.

Fourth, variations in the correlation between the productivity shocks, ρ_{zizf}, change the productivity differentials. A decrease in the correlation leads to larger productivity differences between the sectors and thus imply a higher substitution between formal and informal consumptions. This in turn mainly increases the volatility of output and increases (decreases) the relative volatility of consumption (investment) to output.

Lastly, I vary θ to investigate the role of the mismeasurement of the informal economy. Under the benchmark specification, the reported moments are for the case when none of the informal economy is captured in the country's national accounts, $\theta = 0$ and also when a half of the informal economy is accounted for, $\theta = 0.5$. I consider two other situations when either 10% ($\theta = 0.1$) or 90% ($\theta = 0.9$) of the informal economy is measured and hence included in country's national accounts. Table 6 demonstrates that the mismeasurement of the informal sector mainly affects the magnitude of the relative volatility of consumption to output. In the benchmark case, when the informal sector goes unmeasured, the only sector included in the national accounts is the formal sector. In effect, due to the substitutability between formal and informal consumption over the business cycle, the model generates a relative volatility of consumption to output that is greater than one. However, if the informal sector is measured almost completely ($\theta = 0.9$), then due to the substitutability between the consumption goods, the magnitude of the negative correlation between formal and informal consumption exceeds the one between formal and informal output. As a result, the volatility of output decreases less than the volatility of consumption, which results in the relative volatility of consumption to output that is less than one when most of the informal sector is registered. Furthermore, the decrease in the volatility of output implies an increase in the relative volatility of investment to output since only the formal sector is investment intensive. Changes in the mismeasurement of the informal sector also impact the countercyclicality of trade balance-to-output ratio. The countercyclicality of trade balance-to-output ratio

decreases with a better measurement of the informal activity, since the trade balance-to-output ratio improves after an informal productivity shock while it deteriorates after a formal productivity shock.[30]

6 Conclusion

This paper emphasizes the differences in business cycles between EC and DC and the importance of the informal economy and interest rate fluctuations. It documents the negative relationship between relative volatility of consumption to output and the size of the the informal economy, and also the countercyclicality of interest rates and the trade balance-to-output ratio in EC. The work suggests that the main reason why EC face a relative volatility of consumption to output greater than one is a presence of large informal sector that is poorly measured. I construct a two-sector real business cycle model in a small open economy setting where formal sector firms are subject to the working capital constraint and face country spread and sector-specific productivity shocks. The analysis shows that a model calibrated to Argentine and Mexican data does a fair job of capturing the key patterns of business cycles in these countries.

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[30]This is in line with what I find in the data. In particular, for the sample of countries used in Figure 1 above, I find that the correlation between the size of the informal economy and the cyclicality of trade balance-to-output ratio is about -0.3. In other words, the trade balance-to-output ratio tends to be more countercyclical as the size of informality increases.

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Appendix

This appendix presents Table 8 and Table 9 that show the country sample windows for national accounts and country interest rate data, respectively.

Table 7: Sample Window: National Accounts Data

Country	Start	End	Country	Start	End
Argentina	1993Q1	2016Q3	Italy	1990Q1	2016Q4
Australia	1990Q1	2016Q3	Japan	1990Q1	2016Q4
Austria	1990Q1	2016Q4	Korea	1990Q1	2016Q3
Belgium	1990Q1	2016Q4	Latvia	1992Q1	2016Q4
Bolivia	1990Q1	2015Q4	Lithuania	1993Q1	2016Q4
Botswana	1994Q1	2016Q4	Luxembourg	1995Q1	2016Q4
Brazil	1995Q1	2016Q3	Malaysia	1991Q1	2016Q4
Bulgaria	1996Q1	2016Q1	Malta	1996Q1	2016Q4
Canada	1990Q1	2016Q4	Mexico	1990Q1	2016Q4
Chile	1996Q1	2016Q4	Netherlands	1990Q1	2016Q4
Colombia	1994Q1	2016Q1	New Zealand	1990Q1	2016Q3
Costa Rica	1991Q1	2016Q3	Norway	1990Q1	2016Q4
Croatia	1997Q1	2016Q4	Paraguay	1994Q1	2016Q3
Cyprus	1995Q1	2016Q4	Peru	1990Q1	2016Q3
Czech Republic	1994Q1	2016Q4	Philippines	1990Q1	2016Q4
Denmark	1990Q1	2016Q4	Poland	1995Q1	2015Q1
Ecuador	1991Q1	2016Q3	Portugal	1990Q1	2016Q4
Estonia	1993Q1	2016Q4	Russia	1995Q1	2014Q4
Finland	1990Q1	2016Q4	Singapore	1990Q1	2016Q4
France	1990Q1	2016Q4	Slovakia	1993Q1	2016Q4
Georgia	1996Q1	2016Q2	Slovenia	1995Q1	2016Q4
Germany	1990Q1	2016Q4	South Africa	1990Q1	2016Q4
Hong Kong	1990Q1	2016Q4	Spain	1990Q1	2016Q4
Hungary	1995Q1	2016Q3	Sweden	1990Q1	2016Q4
Iceland	1997Q1	2016Q4	Switzerland	1990Q1	2016Q4
Indonesia	1997Q1	2016Q4	Thailand	1993Q1	2016Q4
Iran	1990Q1	2007Q4	Turkey	1990Q1	2016Q3
Ireland	1997Q1	2016Q4	UK	1990Q1	2016Q4
Israel	1990Q1	2016Q4	USA	1990Q1	2016Q4

Table 8: Sample Window: Interest Rate Data

Emerging Countries	Start	End	Developed Countries	Start	End
Argentina	1994Q1	2016Q1	Australia	1990Q1	2016Q4
Brazil	1996Q2	2016Q1	Austria	1990Q1	2016Q4
Chile	1999Q4	2014Q2	Belgium	1990Q1	2016Q4
Colombia	1999Q3	2016Q1	Canada	1990Q1	2016Q4
Ecuador	1995Q2	2016Q1	Denmark	1990Q1	2016Q4
Hungary	1999Q2	2014Q2	Finland	1990Q1	2016Q4
Malaysia	1997Q1	2014Q2	Netherlands	1990Q1	2016Q4
Mexico	1994Q1	2016Q1	New Zealand	1990Q1	2016Q4
Peru	1997Q2	2016Q1	Norway	1990Q1	2016Q4
Philippines	1999Q3	2014Q2	Portugal	1990Q1	2016Q4
South Africa	2002Q3	2014Q2	Spain	1990Q1	2016Q4
Turkey	1999Q4	2014Q2	Sweden	1990Q1	2016Q4
Venezuela	1994Q1	2016Q1	Switzerland	1990Q1	2016Q4