Should We Expect Financial Globalization to Have Significant Effects on Business Cycles?

by

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SHOULD WE EXPECT FINANCIAL GLOBALIZATION TO HAVE SIGNIFICANT EFFECTS ON BUSINESS CYCLES?

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Abstract. Empirical research suggests that financial globalization has insignificant effects on business cycles. Based on standard theoretical models it might be conjectured that the effects should be significant. I show that this conjecture is wrong. Theoretical effects of financial globalization can be determined to any level of precision by expanding the underlying artificial samples. In contrast, in the data the effects are imprecisely estimated because of short samples. I show that if the conclusion is based on empirically relevant sample sizes, a benchmark international real business cycle model predicts insignificant effects of financial integration for all business cycle statistics except the correlation of consumption. A sensitivity analysis shows that under alternative model structures even the effect on the consumption correlation is insignificant. My results suggest that we should not expect financial globalization to have significant effects on business cycles.

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1. Introduction

Does financial globalization have significant effects on the business cycle? A growing body of empirical literature suggests that the answer is no. Studies in this literature use regression models to investigate whether the volatility and co-movement of key macroeconomic variables are significantly affected by financial globalization. Most papers find insignificant or non-robust effects. Examples of this are Kose, Prasad and Terrones (2003a,b) who use a number of financial integration measures and several business cycle statistics. They find that a particular indicator of integration has a significant effect on the ratio of consumption to income volatility, whereas the effect from an alternative indicator is insignificant. In contrast, the alternative indicator significantly affects the correlation of GDP while the effect from the first indicator is insignificant. A large number of additional business cycle statistics—the standard deviations of total and private consumption, income and GDP and the cross correlation of consumption—are insignificantly affected by either of the two indicators of integration.[1] In this paper, I ask whether we should be surprised to obtain such insignificant effects.

Whether we are surprised or not depends on our prior expectation before seeing the results. In the extent to which this expectation is based on international business cycle models, the findings might seem surprising. According to these models, financial integration affects the business cycle because it increases risk sharing and eases the flow of investments across borders (see e.g. Baxter and Crucini, 1995 and Heathcote and Perri, 2002). Given the theoretical prediction, it is straightforward to conjecture that financial integration has significant effects on business cycles. In this paper, I show that this conjecture is wrong. The reason is that comparing the model predictions with the empirical evidence in this way misses one crucial element: differences in the underlying sample sizes. Theoretical predictions are based on model generated data implying that sample sizes can, in principle, be any size. Hence, the effect of changing the financial market structure can be determined to any level of precision. In contrast, the datasets underlying the empirical results are often quite small implying imprecision in estimated effects and insignificance. Without accounting explicitly for the differences in sample sizes, the precision with which we can determine the effects of financial integration is not determined by the theoretical models. This means that if the theoretical conclusions are based on the shorter samples available to the empirical researcher, it might be the case that standard models also predict insignificant effects of financial integration. The main contribution of the paper is to show that this intuition is correct for a range of conventional models and business cycle statistics. Hence, the main message of the paper is that, according to standard models, we should not expect financial integration to have significant effects on business cycles with the current sample sizes.

[1]Similar results hold across a number of papers. In section 2, I provide a short review of this literature.

This message is important since the expectation in the empirical literature seems to be that financial integration should significantly affect the cycle.[2] This expectation is, in many cases, based on the same theoretical models that I use and is, as I show, correct if samples are sufficiently long. However, when sample sizes resemble those used empirically the effects of financial integration are likely to be insignificant. Hence, the very models that lead us to believe that financial integration affects the cycle, also predict that these effects are insignificant with the current sample sizes. Therefore when the effects then turn out to be insignificant in the data, we should not be surprised.[3]

I develop this result within a benchmark International Real Business Cycle (IRBC) model but also consider a new Keynesian model structure. These models are set up such that financial integration will affect the business cycle. The question is whether the effect is significant when it is estimated on empirically relevant sample sizes. To answer this question, I use a Monte Carlo procedure that involves simulating artificial data from the models and running regressions on the artificial data. The empirical part of the procedure closely matches that of Kose, Prasad and Terrones (2003a,b). In essence, they regress a number of different business cycle statistics on measures of financial integration and some control variables. I do the same with the difference being, of course, that my business cycle statistics are based on artificial data. As mentioned, I primarily use different variants of an IRBC model with productivity shocks as my data generating mechanisms. The IRBC model remains the workhorse of international business cycle analysis and is therefore a natural starting point.[4] The model allows for different international financial market structures and I assume that financial integration corresponds to a move from one structure to another. For instance, in the benchmark model financial integration is a change from a single bond economy to complete financial markets.[5] To determine the short sample prediction of a particular model, I run a large number of regressions and calculate the fraction of regressions where the effect of integration is significant. This fraction is the metric I use to compare the theoretical predictions with the empirical evidence.

The paper combines elements from both the theoretical and empirical literatures on the business cycle effect of financial globalization. The approach in the theoretical literature is to set up a model framework that allows for various international financial

[2]For instance, Kose, Prasad and Terrones (2003b, p. 62) write: "One striking result is that, on average, consumption correlations have not increased in the 1990's, precisely when financial integration would have been expected to result in better risk-sharing opportunities".

[3]It can, obviously, be argued that the theoretical models are misspecified so any result based on these models are wrong. This paper does not try to determine whether models are misspecified or not. Instead, I note that any prior belief about the effects of financial integration on business cycles must be derived from a business cycle model. Since the models I use are standard, they (or a close relative) underlie the expectation of significance in the first place. Hence, arguing that they are misspecified is the same as saying that the initial expectation of significance is wrong.

[4]In a sensitivity check I consider a new Keynesian model with price and wage stickiness affected by both productivity and money supply shocks.

[5]In the sensitivity analysis, I consider financial autarky vs. a single bond economy.

market structures and analyze how changing these affects business cycles (see e.g. Baxter and Crucini, 1995, Heathcote and Perri, 2002 or Sutherland, 1996). The conclusions from this literature are based on long samples generated by the model implying that the effects of integration can be determined to any level of precision. The empirical literature, in contrast, uses linear regression models to investigate whether financial globalization has any effects on business cycles in the data.[6] My analysis borrows from the theoretical literature in the use of macroeconomic models but differs since I focus on the short sample predictions from these models. The way I determine these predictions is borrowed from the empirical literature since I estimate linear regression models on artificial data. My results inform both of these literatures. First, the results highlight the fact that the empirical researcher needs to be careful when comparing her results with the theoretical predictions since the differences in the underlying sample sizes might be able to explain the lack of significance. Second, the theoretical researcher should think about how robustly any possible theoretical effects are determined in the model. A theoretical effect that, according to the model, cannot be detected within a reasonable time frame, is perhaps not that interesting?

The structure of the paper is as follows. In section 2, I review the empirical literature that motivates my study. In section 3, I discuss the theoretical model and the Monte Carlo procedure used to determine the probability of obtaining significant estimates. Section 4 contains my benchmark results, provides some intuition and considers some alternative parameterizations of the model. Section 5 investigates how the results change with the sample size and section 6 offers a few concluding remarks.

2. The Empirical Literature

The econometric strategy used in the empirical literature can be described as follows. The researcher obtains a dataset of aggregate macroeconomic variables for a range of countries over time. The variables commonly used are aggregate consumption, GDP and investment. The dataset also contains indicators of financial integration and control variables believed to affect the dependent variable. Using this data, the researcher calculates standard deviations or cross country correlations of the macroeconomic aggregates.[7] For each business cycle statistic the following regression model is estimated

$$M_i = \beta_1 + \beta_2 FI_i + X_i\alpha + \varepsilon_i \tag{2.1}$$

where M_i indicates the i'th observation of the statistic, FI_i is a vector containing indicators of financial integration and X_i is a vector of control variables.[8]

For instance, Kose, Prasad and Terrones (2003a,b) use annual data from 76 countries over 40 years. They split their sample into four non-overlapping periods of ten years and regress standard deviations (2003a) and cross country correlations (2003b) on two indicators of financial integration. They also control for intensity of trade, relative

[6] See section 2 for a review of this literature.

[7] The data is logged and passed through a filter before the statistics are calculated. Usually, either the first difference, bandpass or HP filter is employed.

[8] Given the panel structure of the dataset, X_i often contains time and/or country fixed effects.

income, a measure of the terms-of-trade volatility and indices of fiscal and monetary policy shocks.

Most empirical papers use either standard deviations or cross country correlations as the business cycle statistic of interest so I divide my review of the literature along these dimensions.

2.1. **Financial Integration and Volatility.** The first paper to consider the impact of financial market integration on macroeconomic volatility is (to my knowledge) Razin and Rose (1994). They regress the standard deviation of consumption, GDP and investment on measures of goods and financial market restrictions using different sets of instrumental variables. They do not find significant effects in any of their primary specifications and use the fact that they cannot distinguish between common and idiosyncratic shocks as a possible reason for this insignificance. Mendoza (1994) argues that the result might be due to the presence of structural breaks in the data. Buch, Doepke and Pierdzioch (2005) use this argument to explain why their integration indicator has no significant effect on output volatility. By splitting their sample into different periods, they show that the effects of integration have changed over time.

Kose, Prasad and Terrones (2003a) consider the effects of financial integration on the volatility of output, income and consumption (both private and total) and the ratio of total consumption to income volatility. They use the "ratio measure" to control for changes in overall volatility. They proxy financial integration using two distinct indicators, namely a *de jure* indicator that measures whether the country has restrictions on capital account transactions and a *de facto* indicator of gross capital flows to GDP.[9] They find that financial integration, as measured by the de facto indicator, has a significant (non-linear) effect on the ratio measure. The effect of the de jure measure is insignificant. Neither the volatilities of GDP, income, private nor total consumption are significantly affected by integration. Bekaert, Harvey and Lundblad (2006) also find a significant effect on consumption growth volatility using a particular measure of integration. The result is, however, not robust: using another measure the effect is insignificant.

2.2. **Financial Integration and Correlations.** I now focus my attention on the cross country correlations. A prominent study is Kose, Prasad and Terrones (2003b). They divide their sample into two groups, the G7 and the rest. Cross correlations are calculated between each country in the "rest" group and an aggregate of the G7 countries. They find that their de jure measure of integration has a significantly positive effect on output correlations but that the de facto measure is insignificantly related to output comovements. Neither financial integration measure has a significant effect on consumption correlations.

[9]The de jure measures of integration used in this literature is in some way or another based on the IMF's AREAER (Annual Report on Exchange Arrangements and Exchange Restrictions) data (Kose et al., 2006). The de facto measures are for the most part based on the work by Lane and Milesi-Ferretti (2001, 2007).

Imbs (2004, 2006) conducts a similar exercise within a simultaneous equation framework. He argues that it is important to determine the indirect effects of financial integration on business cycle correlation. These effects, in his empirical model, work through the degree of specialization which he makes endogenous to financial integration. In Imbs (2004), only the correlation of GDP is considered, whereas both GDP and consumption correlations are analyzed in Imbs (2006). The broad finding is that for most specifications, GDP correlations increase significantly with financial integration. Hence, more integrated countries have more synchronized business cycles. This finding is obtained irrespective of whether a de jure or de facto measure of integration is used. Consumption correlations also increase significantly following integration if the de jure measure is used. This effect, however, is not robust to the use of the de facto measure of integration.

In summary, the empirical literature finds many insignificant and non-robust effects of financial integration. Most business cycle statistics are insignificantly related to integration irrespective of whether a de facto or de jure indicator of integration is used. When significant effects are found these are likely not to be robust. For instance, the prominant studies of Kose, Prasad and Terrones (2003a,b) do find significant effects of financial integration on both output correlations and the ratio of total consumption to income volatility. The effects, however, lack robustness since the indicators that yield significance differ across the two studies. In the remainder of this paper I investigate whether we should be surprised to obtain such insignificant findings.

3. The Model Economy and Monte Carlo Procedure

The models I use as data generating processes are, for the most part, variants of the International Real Business Cycle model (see e.g. Heathcote and Perri, 2002). The main features of the model are the following. The world consists of two countries, Home and Foreign. There are three sectors in each country; a household, an intermediate goods and a final goods sector. Intermediate goods are produced under constant returns to scale using labor and capital services. Final goods are country specific and produced by combining intermediate goods from both countries. Final goods are used for consumption and investment purposes. In the benchmark model the only sources of uncertainty are country specific productivity shocks.

It is outside the scope of this paper to give a fully fledged definition of the process of international financial integration and of how to appropriately model this process. Instead I stress some key points and discuss how financial integration has been modeled in the literature.

In general, it is important to distinguish between *causes* and *effects* of financial integration. A reduction of the costs of conducting international financial transactions is a cause of financial globalization, whereas an observed increase in cross border equity holdings is an effect. Therefore, when modeling financial integration, a natural question becomes whether to focus on the causes or on the effects. Of course, theoretically the most appealing strategy is to model the cause and let the effects be endogenous. The bulk of the theoretical literature has, however, adopted the other strategy; that is to model the effect directly without explanation the cause.[10] A possible reason is that it remains unclear what the main causes of financial integration are.

Since the purpose of this paper is to shed light on aspects of standard models, I follow the bulk of the theoretical literature and model outcomes directly. Hence, I assume without explanation that households have access to one of two international financial market structures when trading with households abroad. In the benchmark model, households can trade in a single bond (before financial integration) or have access to complete financial markets (after integration). I also compare financial autarky with the single bond economy.

Since the model is standard in the literature, I relegate a detailed description to the appendix. Different parameterized versions of the model are used to generate artificial data that is an important input into the Monte Carlo procedure.

3.1. **The Monte Carlo Procedure.** In essence, the Monte Carlo procedure consists of two loops, where the first loop simulates artificial data and the second runs regressions and calculates test statistics. For the main part of the paper, I set the sample size and number of observations in the regressions to match Kose, Prasad and Terrones (2003a,b). As discussed in section 2, they use annual data over 40 years (1960-1999) from 76 countries. They split the sample into four non-overlapping periods of 10 years, which leaves around 250 observations of each business cycle measure.[11] As explained in section 2, these observations are regressed on a number of explanatory variables including indicators of financial integration.

The numerical algorithm also involves regressing 250 observations of a particular volatility or comovement measure on an indicator of financial integration. I use standard deviations and cross country correlations of GDP, consumption and investment as business cycle measures. Moreover, I consider two ratio measures, namely the standard deviation of investment and consumption relative to the standard deviation of GDP. These correspond to the bulk of the measures used in the empirical literature. In my framework, the indicator for financial integration is a dummy that takes the value of one if the measure is from the model with more integrated financial markets. The only remaining control variable is a constant.[12] More precisely, I run the following simple version of (2.1)

$$M_i = \beta_1 + \beta_2 FI_i + \varepsilon_i \tag{3.1}$$

where FI is the dummy.

[10] Sutherland (1996) and Heathcote and Perri (2004) are exceptions.

[11] The precise number of observations varies slightly across the different specifications considered by Kose, Prasad and Terrones (2003a,b). I retain 250 observations throughout section 4.

[12] The only difference between the theoretical models is the structure of financial markets. Hence, including additional regressors—e.g. the terms of trade, indices of monetary policy shocks etc.—is superfluous. Moreover, it uses degrees of freedom and would therefore bias the results against finding significant estimates.

Testing whether financial integration affects the business cycle is a test of whether $\beta_2 = 0$. In this simple framework, β_1 and $\beta_1 + \beta_2$ have some straightforward interpretations. β_1 is the average value of the measure, M, in the financially less integrated model across the 250 observations in the regression. Similarly, $\beta_1 + \beta_2$ is the average value in the more integrated financial market version of the model.

I now describe the numerical algorithm in detail. The algorithm involves five steps:

(1) Choose a particular parameter for the theoretical model. Set $i = 1$ and $j = 1$.
(2) Simulate a time series of k periods from either the more or less financially integrated version of the model, flipping a fair coin to determine the financial structure.
(3) HP-filter the time series and calculate standard deviations and cross country correlations of consumption, GDP and investment. Set $i = i + 1$. If $i = n$, go to 4, otherwise return to 2.
(4) For each measure, estimate model (3.1) and calculate the robust t-statistic of a test of whether $\beta_1 = 0$. Compare the statistic with the two-sided 5% critical values from the t distribution using $n - 2$ as degrees of freedom. Record whether the test rejects the null. Also, when the null is rejected, record whether $\beta_2 < 0$ or $\beta_2 > 0$.
(5) Set $j = j + 1$. If $j = m$, stop the algorithm, otherwise set $i = 1$ and return to 2.

The procedure requires a number of comments. The papers by Kose, Prasad and Terrones (2003a,b) use annual data. My theoretical model is calibrated to quarterly data, so to get annual data I aggregate the quarterly data using the relation: $\hat{x}_t^a = \left(\hat{x}_t^{q1} + \hat{x}_t^{q2} + \hat{x}_t^{q3} + \hat{x}_t^{q4}\right)/4$. Here a hat denotes log deviation from steady state and superscript a or q indicates annual or quarterly observations.[13] After aggregation I have 10 years of annual observations ($k = 10$) which are HP filtered using $\lambda = 100$ as smoothing parameter.[14] As mentioned I use 250 observations in each regression, so $n = 250$. Finally, I calculate robust t-statistics because there is evidence of heteroskedasticity.

The outcome of the Monte Carlo procedure is the fraction of the m regressions in which the effect of financial integration has the expected sign and is significant. I denote this fraction the probability of significance. In essence, this probability measures the statistical power of the t-test. If a given model gives rise to a probability of significance close to zero, the prediction from the model is that the effect of financial integration is likely to be insignificant.

Whereas the choices of k and n are set as in Kose, Prasad and Terrones (2003a,b), the choice of m is free. In theory, by letting $m \to \infty$ I will obtain the true power of the t-test. In practice, experiments indicated that $m = 2000$ was sufficient for convergence.

[13] I aggregate quarterly data into annual observations because I want to consider a new Keynesian model in the sensitivity analysis. With annual observations it is difficult to calibrate Calvo price and wage stickiness parameters. Using an IRBC model calibrated to annual data did not change the conclusions.

[14] Using a first difference filter does not change the results.

4. Results

This section contains the main results of the paper. I start by considering a benchmark international real business cycle model. This model is at the core of most international business cycle analyses and is, therefore, a natural starting point for my analysis. Using this model, the results from the Monte Carlo procedure show that financial integration is likely to have insignificant effects on the business cycle. In fact, the only business cycle statistic for which the probability of significance is more than half is the correlation of consumption. After presenting these results, I provide some intuition and conduct an extensive sensitivity analysis.

4.1. **The Benchmark Model.** I consider a calibration of the IRBC model close to the one used by Heathcote and Perri (2002). The risk-aversion coefficient is set to two ($\sigma = 2$) and the Frisch elasticity of labor supply is set to one half, so $\phi = 2$. Moreover, I set the intratemporal elasticity of substitution between intermediate goods $\theta = 1.5$ and the weight on different intermediate goods in final goods production, $\zeta = 0.85$. Heathcote and Perri (2002) use $\theta = 0.9$ and $\zeta = 0.85$ in their analysis. Productivity shocks follow a $VAR(1)$ process with $\rho = 0.964$ as the autocorrelation coefficient and $\varpi = 0.035$ as the spill-over coefficient. The standard deviation and cross country correlation of the innovations are 0.0065 and 0.1731 respectively.[15] Financial integration corresponds to a move from a single bond economy to complete financial markets.

Table 1 reports the results from the Monte Carlo procedure when the data is generated by the benchmark model.

Table 1: Monte Carlo Results, Benchmark Model

	Single Bond	Complete Markets	Difference	Fraction of times t-test indicates		
	Beta1	Beta1 + Beta2	Beta2	Beta2 < 0	Beta2 = 0	Beta2 > 0
corr(cons)	0.7275	0.8491	0.1216	0.0000	0.0015	**0.9985**
	0.0217	*0.0144*	*0.0258*			
std(cons)	0.0165	0.0160	-0.0005	**0.0880**	0.9085	0.0035
	0.0005	*0.0005*	*0.0007*			
std(cons)/std(GDP)	0.6509	0.6342	-0.0167	**0.1570**	0.8430	0.0000
	0.0120	*0.0137*	*0.0183*			
corr(invest)	-0.5098	-0.5152	-0.0054	**0.0320**	0.9505	0.0175
	0.0302	*0.0303*	*0.0418*			
std(invest)	0.0686	0.0690	0.0004	0.0180	0.9480	**0.0340**
	0.0019	*0.0019*	*0.0028*			
std(invest)/std(GDP)	2.7217	2.7286	0.0069	0.0210	0.9550	**0.0240**
	0.0479	*0.0480*	*0.0669*			
corr(GDP)	0.1327	0.1243	-0.0083	**0.0330**	0.9535	0.0135
	0.0383	*0.0392*	*0.0537*			
std(GDP)	0.0258	0.0259	0.0001	0.0175	0.9560	**0.0265**
	0.0007	*0.0008*	*0.0011*			

Note: Monte Carlo results using 2000 regressions. Columns 2-4: Average coefficients across 2000 regressions. Standard deviation of the coefficients in italics. Columns 5-7: pow er of t-test on Beta2.

[15] I estimate the parameters of the $VAR(1)$ process using US and European data—see the data appendix for details.

Each row of the table corresponds to regressions on a particular business cycle measure as indicated by the first column. Columns two, three and four report the averages of β_1, $\beta_1 + \beta_2$ and β_2 respectively and the corresponding sample standard deviations over 2000 regressions. The right-hand side of the table reports the fraction of times the t-test indicates that β_2 is significantly negative, not significant and significantly positive at the 5% level. The bold face entries are the probabilities of significance; that is, the fraction of regressions the t-test rejects the null hypothesis ($\beta_2 = 0$) in favor of the true alternative.

The Difference column shows that financial integration increases the correlation and decreases the standard deviation of consumption. Trading in complete financial markets allows for further sharing of consumption risks, which makes consumption profiles less volatile and more synchronized across borders. Investment becomes less synchronized and more volatile following financial integration essentially because investment flows more easily. Under the benchmark parameterization, GDP becomes more volatile and less synchronized across countries.

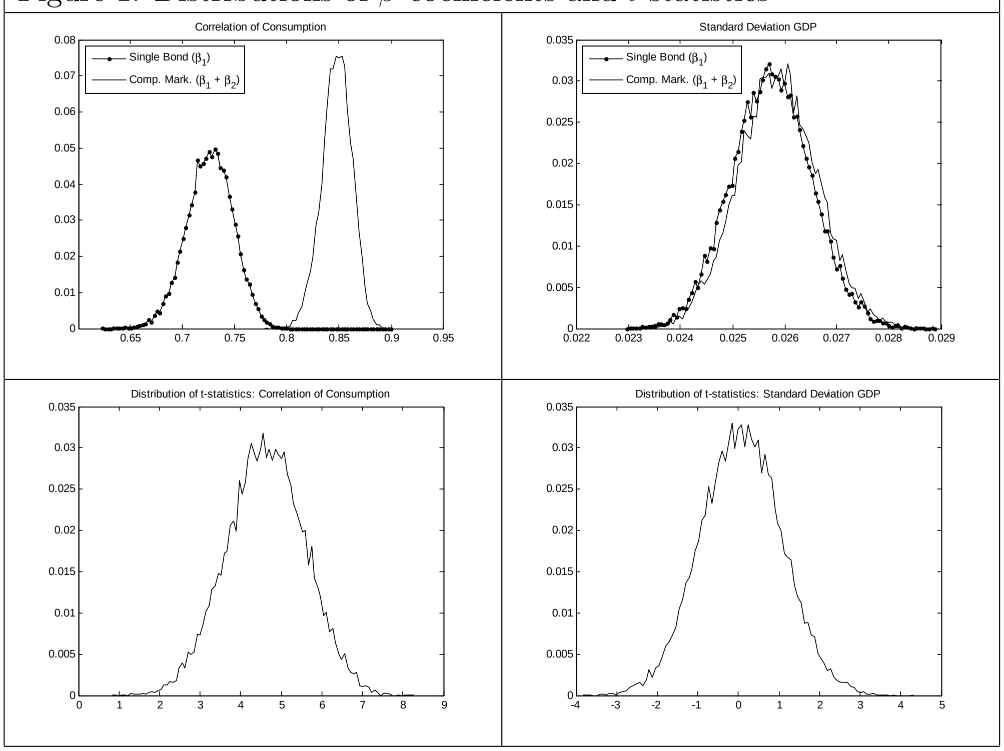
The table also shows that the effect of integration is imprecisely estimated for many business cycle statistics. For instance, the average effect of integration on the standard deviation of consumption is -0.05%, but the standard deviation is 0.07%. Hence, an estimated increase in the standard deviation is completely plausible and actually occurs in around 22% of the regressions. The imprecision of the estimates gives rise to low power in the associated t-test. The table shows that the effect of integration on the standard deviation of consumption is significantly negative in less than 9% of the regressions. For the relative volatility of consumption to GDP the probability of significance is slightly larger. For this statistic, the effect of integration is significantly negative in around 16% of the regressions. The probability of insignificance is less when considering the GDP and investment statistics. For these measures, the likelihood of attaining a significant effect with the correct sign is smaller than 5%. The only measure where the probability of significance is larger than 50% is the correlation of consumption. Using this business cycle statistic, the effect of integration is significant in practically all regressions.

I now provide some intuition for the results. The top row of Figure 1 shows distributions of β_1 and $\beta_1 + \beta_2$ for the correlation of consumption and standard deviation of GDP. A key point to notice from the figure is that the estimated β's vary substantially. This variation is a reflection of the fact that different economies are subject to different shocks. As the figure shows, this implies that even if the financial market structure is the same, the business cycle statistics can be very different. If this variation is large compared with the average effect of integration, the estimated effect is likely to be insignificant and can even be significant, but have the "wrong" sign. Notice that the variation of the β's is driven by the stochastic nature of the model and the short sample size. In other words, imprecision will characterize the estimates no matter what stochastic business cycle model I use as data generating process.

Figure 1 shows that for the correlation of consumption the average effect of financial integration is large compared with the standard deviation of the effect.[16] This implies that most of the associated t-statistics are larger than the critical value of around $t = 1.97$. To the contrary, the effect of financial integration on the standard deviation of GDP is quite small. For this measure the distributions of β_1 and $\beta_1 + \beta_2$ are virtually on top of each other. This implies that the t-statistics are within the boundaries of the critical values meaning a large probability of insignificance. Moreover, the probability of obtaining significant estimates with the wrong sign is not much smaller than the probability of obtaining significant estimates with the "correct" sign—see Table 1.

The variation in estimates is an inverse function of the size of the sample underlying the estimation. With larger sample sizes, either in terms of the number of observations in each regression or the number of periods underlying the calculation of each business cycle statistic, the variation falls and the probability of significance increases. In Section 5, I examine how sensitive the power statistics are to variation in the underlying sample size.

Figure 1: Distributions of β coefficients and t-statistics



[16]The distribution of t-statistics emerges by drawing repeatedly from the single bond and complete markets model, subtracting the draws and dividing the difference with the associated standard error. This standard error can be approximated by the square root of the sum of the variances of the β_1 and $\beta_1 + \beta_2$ distributions.

4.2. **Sensitivity Analysis.** The main purpose of this subsection is to show that the results from the benchmark model hold across a range of models. I do this in two steps. First, I retain the benchmark model structure and examine how the results vary with some key parameters. Second, I change the model structure by allowing alternative modeling assumptions regarding financial integration and nominal rigidity.

A number of results emerge from this analysis. First, under the benchmark modeling of financial integration, the business cycle statistics based on consumption often have a larger probability of significance compared to the statistics based on investment and GDP. Second, introducing nominal rigidity and shocks does not overturn this conclusion. Third, modeling financial integration in a different manner has a major impact on the results. If financial integration corresponds to a change from financial autarky to a single bond economy, consumption based statistics have a lower probability of significance compared to investment and GDP statistics. Fourth, model structures exist where the probability of significance for any business cycle statistic is close to zero. Hence, on the basis of a range of models the results suggest that financial integration should have insignificant effects on the business cycle.

4.2.1. *Varying the Benchmark Model Parameters.* Table 2 shows the probabilities of significance under four alternative calibrations of the IRBC model. To ease comparison, the first column shows the probabilities from the benchmark calibration.

Table 2: Probabilities of Significance, Variations of Benchmark Model Parameters

	Benchmark Model	Infinite Frisch Elasticity	Log Utility of Consumption	Persistent Productivity	Larger Substitutability
		Phi = 0	Sigma = 1	Rho_A = 0.999	Theta = 5
corr(cons)	0.9985	0.7830	0.4990	1.0000	1.0000
std(cons)	0.0880	0.1015	0.0625	0.9850	0.2900
std(cons)/std(GDP)	0.1570	0.6230	0.2115	1.0000	0.5675
corr(invest)	0.0320	0.0925	0.0390	0.5690	0.1730
std(invest)	0.0340	0.1420	0.0355	0.5165	0.2695
std(invest)/std(GDP)	0.0240	0.0475	0.0610	0.8610	0.0370
corr(GDP)	0.0330	0.1990	0.0210	0.1605	0.3545
std(GDP)	0.0265	0.1490	0.0240	0.0665	0.2200

Note: Monte Carlo results using 2000 regressions.

In the first experiment, I change the responsiveness of labor supply to wage changes. Studies based on microdata show that the labor supply elasticity is near zero, implying large values of ϕ. However, Hansen (1985) provides an example where the labor supply elasticity of the representative agent is different from that of individual agents. In his example, the labor supply elasticity is zero at the micro level, but infinite for the representative agent. Column two shows the results from the Monte Carlo procedure when ϕ is at 0 and all other parameters are retained at their benchmark value. The table shows that the probabilities of significance change only slightly compared to the benchmark case. Quantitatively the largest effects are for the correlation and relative volatility of consumption. The probability of significance decreases for the former measure but increases for the latter. For the correlation of consumption, the lower probability of significance is primarily caused by less precise estimates. Hence, with a more flexible labor supply the correlation of consumption varies more across simulations. In contrast, the larger probability of obtaining significant estimates of the relative volatility of consumption is caused by a larger average effect of integration. The probability of significance increases slightly for the remaining business cycle measures, but the change is quantitatively small.

The next experiment I consider is varying σ, the coefficient of relative risk aversion. In the real business cycle literature, σ has often been set at unity, corresponding to log utility of consumption, since this value is consistent with balanced growth. However, in the international business cycle literature, values of $\sigma > 2$ are not uncommon.[17] Table 2 shows the results from the Monte Carlo procedure if $\sigma = 1$.[18] As with the labor supply elasticity, changing risk aversion has little effect on the power statistics. In fact, the only measure where the probability of significance changes substantially is the correlation of consumption. This probability is lower with less risk averse households. The reason is both a lower average effect of integration and less precision in the estimates of this effect. In summary, the probability of obtaining significant estimates does not depend strongly on the benchmark values of ϕ and σ.

Column four reports the results from the Monte Carlo procedure when productivity shocks are near unit root processes, $\rho^A = 0.999$.[19] With unit root productivity shocks, business cycle statistics based on consumption are very likely to be significant. In fact, the probability of significance is larger than 98% for the three consumption based business cycle statistics. Also the statistics based on investment and GDP are more likely to be significant with more persistant productivity shocks, albeit the change is not as large as for the consumption based statistics. For instance, the statistics based on GDP are still insignificant in more than 80% of the regressions. The larger probabilities of significance are a reflection of the fact that financial integration (under the benchmark modeling assumption) has quantitatively larger effects when productivity is a near unit root process. As Baxter and Crucini (1995) and Iversen (2009) explain, when income shocks are permanent there is no ex post consumption smoothing incentive. This implies that when households have access to a single bond only, there is no transfer of purchasing power to the relatively low income country so consumption behavior is very different across countries. This contrasts with the complete markets framework, where there is ex ante insurance. Under this market framework, households have agreed to share purchasing power, implying that consumption responds similarly across countries regardless of the persistency of the shocks. Hence, when shocks are close to permanent, the additional risk sharing opportunities offered by the financial market imply substantial changes in consumption behavior and therefore in β_2 estimates.

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[17] Chari, Kehoe and McGrattan (2002) show that $\sigma = 5$ is needed to capture the empirically observed volatility of the real exchange rate in standard models.

[18] I also experimented with $\sigma = 5$. Except for slightly larger probabilities of attaining significant GDP volatility and comovement measures, the results are essentially unchanged.

[19] I follow Heathcote and Perri (2002) and adjust ϖ^A so the largest eigenvalue of the coefficient matrix in the VAR remains constant.

Now consider how the results change with the intratemporal elasticity of substitution, θ. Cole and Obstfeld (1991) pointed out that the value of θ is important in determining the effects of changing the financial market structure. Micro studies usually find values of θ ranging from 4 to 15, whereas estimates based on macro time series data usually obtain values from 1 to 3 (Coeurdacier, 2009). Column five shows the results from setting $\theta = 5$.

In general, the column shows that the probability of obtaining significant effects of integration is larger when $\theta = 5$ compared to the benchmark calibration. Notice, however, that the probability of obtaining significant estimates is still quite low. In fact, all but two business cycle statistics are significantly affected by financial integration in less than 40% of the regressions. To get intuition for the increase, notice that productivity shocks have both a direct and an indirect effect on relative income. The direct effect is related to the fact that with larger productivity, more output can be produced with the same level of inputs. For any given terms of trade, this effect increases relative income. However, in general equilibrium the relatively productive country will experience a terms of trade depreciation because it produces more output. This effect tends to reduce relative income. While the direct effect is independent of θ, the indirect effect becomes smaller the larger θ is. In the limit, as $\theta \to \infty$, outputs in different countries become perfect substitutes and the terms of trade are always unity. Hence, for larger values of θ relative income responds more to shocks, increasing the effect of changing the financial market structure. Hence, the result from the figure is as we should expect: the probability of obtaining significant estimates increases with θ.

I also tried a number of different calibrations of θ. Increasing the elasticity of substitution from $\theta = 5$ in general increases the probabilities of significance, but even with $\theta = 15$ many important business cycle statistics are significant in less than 50% of the regressions. For instance, the probabilities of significance for the standard deviation of consumption and GDP are around 33% and 45% when $\theta = 15$. I also considered a calibration where $\theta = 0.9$ as used by Heathcote and Perri (2002). Under this calibration the probability of obtaining significant estimates is close to zero for all business cycle statistics (not shown). An example is that the probability of significance for the correlation of consumption is significantly affected by integration is less than 10% in this case. The intuition follows directly from above. When the elasticity of substitution is close to unity, the movements in the terms of trade adjust so that relative income does not change much following a shock. Hence, the effect of financial integration is low implying a large probability of insignificance.

I also experimented with other calibrations of the stochastic process driving productivity. Baxter and Crucini (1995) argue that it is difficult to determine the precise values of the autocorrelation $\left(\rho^A\right)$ and spill-over term $\left(\varpi^A\right)$ in the productivity shock process. Correspondingly, I also tried a calibration with $\rho = 0.908$ and $\varpi = 0.088$ as used in Backus, Kehoe and Kydland (1992). With this calibration all business cycle statistics except the correlation of consumption have probabilities of significance of less than 10%.

4.2.2. *Modeling Financial Integration Differently.* In the benchmark model, integration corresponds to changing the financial market structure from a single bond economy to complete markets. However, as Heathcote and Perri (2002) show, a model with financial autarky is better at capturing key aspects of the data, implying that the "before" financial integration situation is, perhaps, better captured by the autarky situation. It could also be argued that complete markets is not the proper way to model the "after" integration situation.

Correspondingly, I assume that financial integration amounts to a move from financial autarky to the single bond economy. Table 3 shows the results from the Monte Carlo procedure in this case using the benchmark calibration of the parameters.

Table 3: Monte Carlo Results, Financial Autarky vs. Single Bond

	Financial Autarky	Single Bond	Difference	Fraction of times t-test indicates		
	Beta1	Beta1 + Beta2	Beta2	Beta2 < 0	Beta2 = 0	Beta2 > 0
corr(cons)	0.7662	0.7609	-0.0053	**0.0390**	0.9490	0.0120
	0.0203	*0.0212*	*0.0291*			
std(cons)	0.0160	0.0160	0.0000	0.0165	0.9595	**0.0240**
	0.0005	*0.0005*	*0.0007*			
std(cons)/std(GDP)	0.6320	0.6048	-0.0272	**0.3270**	0.6730	0.0000
	0.0128	*0.0128*	*0.0182*			
corr(invest)	-0.3985	-0.6349	-0.2364	**1**	0	0
	0.0336	*0.0253*	*0.0412*			
std(invest)	0.0658	0.0864	0.0206	0	0	**1**
	0.0019	*0.0024*	*0.0031*			
std(invest)/std(GDP)	2.5987	3.2877	0.6890	0	0	**1**
	0.0399	*0.0638*	*0.0742*			
corr(GDP)	0.1639	0.0634	-0.1005	**0.4495**	0.5505	0.0000
	0.0380	*0.0395*	*0.0538*			
std(GDP)	0.0258	0.0270	0.0013	0.0015	0.7885	**0.2100**
	0.0007	*0.0008*	*0.0011*			

Note: Monte Carlo results using 2000 regressions. Columns 2-4: Average coefficients across 2000 regressions. Standard deviation of the coefficients in italics. Columns 5-7: power of t-test on Beta2.

In contrast to the benchmark model, business cycle statistics based on GDP are now more likely to be significant than consumption based statistics. For instance, the probability that the correlation of consumption is significant is now about 4%. This should be seen in relation to a probability of significance of more than 99% in the benchmark model. Hence, the precise way financial integration is modeled is crucial for the conclusions. Notice from the table that the investment measures are always significant under the present modeling of integration. Under financial autarky, investment equals savings so by removing this link, financial integration affects investment behavior substantially. Also the GDP based statistics are more likely to be significant with the current modeling of financial integration. The cross correlation of GDP is significant in a bit less than half of the regressions, whereas the standard deviation is significant in around a fifth of the cases. Notice also that the qualitative effects of integration on the correlation and standard deviation of consumption are different compared to the benchmark model: consumption becomes less synchronized and more volatile with financial integration.[20]

These results highlight the fact that it is not given that financial integration always affects consumption behavior in a significant manner but depends on the precise nature of financial integration. In the present model, financial integration does not provide any ex ante consumption insurance, implying that the behavior of consumption does not change much with integration. In contrast, decoupling saving from investment matters a lot so investment behavior is radically different following integration. The changed investment behavior drives a change in the behavior of GDP that is more likely to be affected by integration than in the benchmark case.

4.2.3. *The New Keynesian Model.* The final experiment I consider is to introduce imperfect competition, nominal rigidities and nominal shocks into the model. Sutherland (1996) shows that the business cycle effects of financial integration might vary across the sources of shocks hitting the economy. Also, Iversen (2009) shows that the effects of financial integration are large in an economy buffeted by nominal shocks only.

I introduce imperfect competition in two ways. First, I assume that labor markets are characterized by imperfect competition modeled using household/unions á la Erceg, Henderson and Levin (2000). Second, I follow Chari, Kehoe and McGrattan (2002) and assume that intermediate goods are sold under monopolistic competition. Both nominal wages and intermediate goods prices are staggered modeled as in Calvo (1983). I introduce money shocks by assuming that nominal money supply growth follows a $VAR(1)$ process. Money demand arises because real money enters the utility function. I introduce both nominal prices and wages because the results of Iversen (2009) indicate that the interaction of wage rigidity and nominal shocks is important in generating large quantitative effects of financial integration. As in the benchmark model, financial integration corresponds to a change from a single bond economy to complete financial markets.

I set the probability that prices and wages are revised to 25% per quarter. The elasticities of substitution in the wage and intermediate goods sector such that the steady state mark-up is 10%. I estimate the parameters of the money growth process using data from the US and Germany but the results are robust to variations of these parameters.

Table 4 reports the results from the Monte Carlo procedure when the data is generated by the new Keynesian model.

[20]Notice, however, that the volatility increase is very small.

Table 4: Monte Carlo Results, New Keynesian Model

	Single Bond	Complete Markets	Difference	Fraction of times t-test indicates		
	Beta1	Beta1 + Beta2	Beta2	Beta2 < 0	Beta2 = 0	Beta2 > 0
corr(cons)	0.4081	0.5957	0.1876	0.0000	0.0250	**0.9750**
	0.0380	*0.0295*	*0.0480*			
std(cons)	0.0137	0.0129	-0.0008	**0.2555**	0.7440	0.0005
	0.0004	*0.0004*	*0.0006*			
std(cons)/std(GDP)	0.6707	0.6337	-0.0370	**0.5580**	0.4420	0.0000
	0.0113	*0.0133*	*0.0173*			
corr(invest)	0.2960	0.3017	0.0057	0.0175	0.9500	**0.0325**
	0.0351	*0.0337*	*0.0481*			
std(invest)	0.0491	0.0489	-0.0002	**0.0320**	0.9495	0.0185
	0.0013	*0.0013*	*0.0019*			
std(invest)/std(GDP)	2.4633	2.4519	-0.0114	**0.0435**	0.9445	0.0120
	0.0434	*0.0461*	*0.0650*			
corr(GDP)	0.1490	0.1413	-0.0077	**0.0360**	0.9500	0.0140
	0.0415	*0.0399*	*0.0567*			
std(GDP)	0.0207	0.0207	0.0000	0.0175	0.9560	**0.0265**
	0.0006	*0.0006*	*0.0009*			

Note: Monte Carlo results using 2000 regressions. Columns 2-4: Average coefficients across 2000 regressions.
Standard deviation of the coefficients in italics. Columns 5-7: power of t-test on Beta2.

The model produces larger probabilities of significance compared to the benchmark model, for two of the three consumption based statistics. For instance, the standard deviation of consumption is now significantly affected by integration in around a fourth of the regressions. In the benchmark model, this number was 9%. Also the probability that the relative consumption volatility is significant increases, and is, in the new Keynesian model, more than 55%. The probability that the correlation of consumption is significantly affected is slightly less than in the benchmark model. The larger probability of obtaining significant estimates is caused by a larger average effect of integration. Under rigid nominal wages, the response of relative income is more persistent following nominal shocks, implying that the effects of financial integration are larger (Iversen, 2009).

For the remaining business cycle statistics, the probabilities of significance are low, as in the benchmark model. It is worth noting that the qualitative effects of financial integration on investment are different from the benchmark model. This is, however, not a robust feature of the new Keynesian model and I do not go into further detail on this point here.

This section shows that it is relatively easy to set up models where the effect of financial integration is likely to be insignificant with the current sample sizes. This means that the expectation these models allows us to have before seeing the empirical results is *not* that financial integration has significant effects on business cycles. Instead, based on an overview of the results from these models, we should not be surprised to obtain insignificant effects in the data.

5. Varying the Sample Size

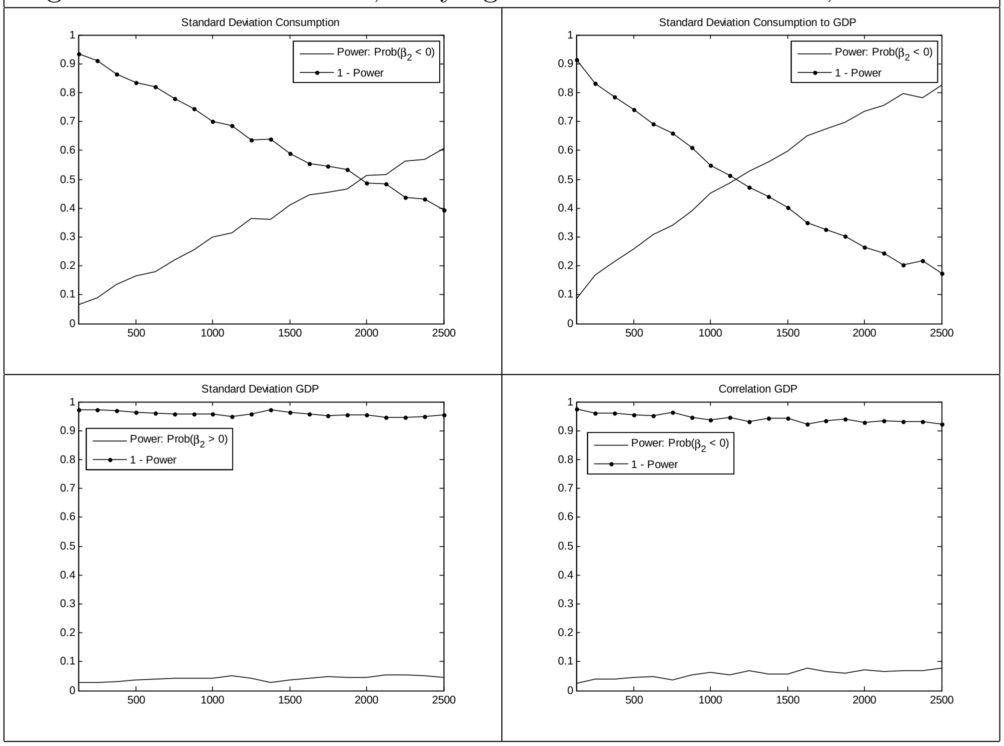
In the previous section, I analyzed how the probability of significance varied with the model structure while retaining the sample size constant. In this section I conduct the alternative exercise and examine how the likelihood of significance varies with the sample size but maintain the benchmark model as the data generating process. The purpose is twofold. First, I want to highlight that the reason why many estimates are insignificant is due to short samples. With sufficiently long samples the effects of integration are always significant. The important question is, therefore, how long "sufficiently long" is. Shedding light on this question is the second purpose of the section.

I study how the probabilities of significance changes with sample sizes along two dimensions. First, I change the sample sizes underlying the calculation of each business cycle measure and, second, I vary the number of observations in the regressions. To understand why an overall increase in available data can increase either of these two terms, recall the approach used in the empirical literature. Here the researcher obtains a panel dataset of macroeconomic variables of, say, 40 annual observations spanning a range of countries. The annual observations are then split into a number of periods and the measure of comovement or volatility is calculated on data from these periods. Each of these measures is regarded as a separate observation of the dependent variable.[21] It follows that the larger the number of periods, the larger the number of observations of the dependent variable, but also the lower number of periods are underlying the calculation of each dependent variable. For instance, in the benchmark model $k = 10$ and $n = 250$, meaning there are 10 annual observations underlying the calculation of, say, the standard deviation of consumption. Instead, with the same dataset, it is possible to choose $k = 5$ implying $n = 500$. In this section, I analyze the consequences of increasing first the number of observations of the dependent variable, n, and second the number of annual observations underlying the calculating of each dependent variable, k.

[21]Kose, Prasad and Terrones (2003a,b) use four periods implying 10 annual observations of the macroeconomic variable in each period.

Figure 2 plots power as a function of n in the benchmark model.[22]

Figure 2: Power Statistics, Varying number of observations, n

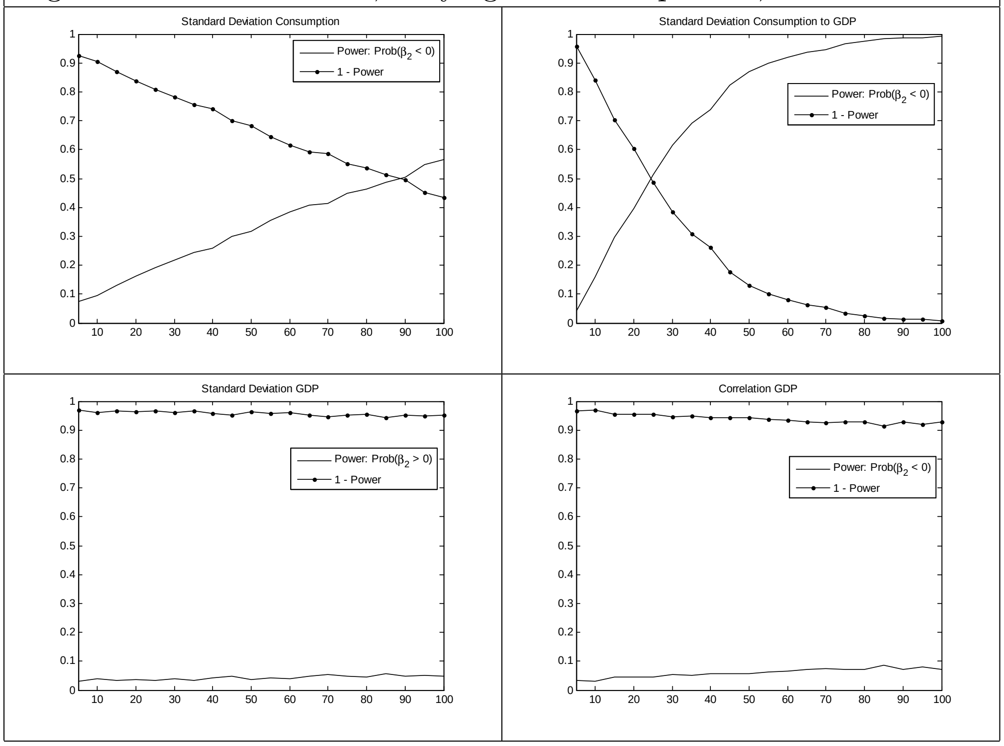


First, notice that power increases with the number of observations in the regressions. For instance, for the standard deviation of consumption, the probability of insignificance decreases from more than 90% to around 60% across the values of n. A similar result holds for the relative standard deviation of consumption. This illustrates that insignificant estimates are a short-run problem. With sufficiently large samples, the effects will always be significant. A second thing to notice is that the increase in the probability of significance varies considerably across business cycle measures. For instance, the increase for the standard deviation and correlation of GDP is hardly noticeable. Hence, even with $n = 2500$—which corresponds to ten times as much data as is used in Kose, Prasad, and Terrones (2003a,b)—it is still very likely that financial integration has no significant effect on GDP measures. The reason is that even with $n = 2500$, the imprecision in the estimation is still large compared with the average effect. For instance, for the standard deviation of GDP, the average effect of financial integration is only a third of the estimated standard deviation of this effect.

[22] I focus on the standard deviation measures of consumption and the standard deviation and correlation of GDP. The probability of obtaining a significant effect on the correlation of consumption is close to unity for all values of n.

Figure 3 explores whether increasing k, the number of annual periods underlying the calculating of the business cycle measures, changes this conclusion.

Figure 3: Power Statistics, Varying number of periods, k



In general, the results are similar to those from Figure 2: the effect of increasing k is largest for the consumption measures and hardly detectable for the GDP measures. With $k > 90$, the probability that the volatility of consumption relative to GDP is significantly affected by integration is close to 100%. $k = 90$ corresponds to nine times as much data as used by Kose, Prasad and Terrones (2003a,b), which is more than 350 years of data.

The conclusion from this section is that even though the problems of obtaining significant effects of financial integration is a short run problem, the short run might be quite long. At least for the GDP measures, the results from this section indicate that having access to ten times as much data, would not do much difference: the effects of financial integration would still very likely come out insignificant.

6. Conclusion

Standard theoretical business cycle models predict that financial globalization will affect the cycle. The question asked in this paper is whether we should expect the effect to be significant. In the extent to which the expectation is based on a range of standard international macroeconomic models, the answer is no: the probability of significance is low across many plausible model parameterizations and business cycle statistics. An implication is that we should not be surprised when financial integration has mere insignificant effects on business cycles in the data: many standard models have exactly this prediction.

Even though the results are based on tightly parameterized models, I argue that they are more general and are likely to extend to many other model frameworks. The reason is twofold. First, it is a well known result that changing the international financial market structure has a limited quantitative effect on business cycle statistics in standard international macroeconomic models. This means that the average effect of integration is small according to these models. Second, estimating business cycle statistics from a small sample induces substantial imprecision in the estimate when the data is generated by a stochastic model. The combination of these two effects is likely to induce large probabilities of insignificance across many theoretical frameworks.

My results give rise to a number of remarks and suggestions for future research. First, the results are based on, I would argue, standard international macroeconomic models. Using these models is a natural starting point, since the models are often envoked when motivating why financial globalization should affect the business cycle. However, the above discussion suggests that the limited quantitative effect of financial integration in these models is an important factor behind the many insignificant effects. Future research should determine whether these models are appropriate frameworks in which to understand aspects of international financial integration. Second, my insignificant results are a product of small sample sizes. Empirical studies are likely to suffer from additional econometric problems such as, for instance, endogenous regressors, measurement error and non-linear effects. If these problems are not properly accounted for in the empirical analysis the estimated effect of integration is numerically small and more likely to be insignificant. Hence, even if financial integration changes the business cycle substantially, it might be difficult to pick up these effects in the data. More empirical work is needed to account for these problems, thereby allowing a better understanding of how financial globalization affects business cycles.

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Appendix

The Model Economy. I set up a general model that nests both the IRBC and new Keynesian models used in the main text under appropriate settings of the parameters. The world consists of two countries Home and Foreign, both of size unity. There are three sectors in each country; a household/union, an intermediate goods and a final goods sector. Intermediate goods and labor supplies are sold under monopolistic competition with prices and wages subject to staggering as in Calvo (1983). Final goods are country specific and produced by combining intermediate goods from both countries. Final goods are used for consumption and investment purposes. Each country is affected by both productivity and money supply shocks.

The Household Sector. Under complete markets, households solve

$$
\begin{aligned}
& \max E_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{(c_t)^{1-\sigma}}{1-\sigma} + \log\left(\frac{M_t}{P_t}\right) - \frac{(h_t)^{1+\phi}}{1+\phi} \right] \\
& st.P_t c_t(i) + P_t x_t(i) + E_t Q_{t,t+1} B_{t+1}^C(i) + M_t(i) \\
= \; & B_t^C(i) + M_{t-1}(i) + P_t r_t k_{t-1}(i) + W_t(i) h_t(i) + T_t(i) + \Pi_t(i) \\
& k_t = (1-\delta) k_{t-1} + x_t - \Phi\left(\frac{x_t}{k_{t-1}}\right) k_{t-1}
\end{aligned}
$$

Here $c_t(i), \frac{M_t(i)}{P_t}, h_t(i), x_t(i)$ and $k_{t-1}(i)$ are consumption, real money, labor supply, investment and the capital stock of household i in period t. P_t is the price of the consumption/investment good, r_t is the real gross return to capital, $W_t(i)$ is the nominal wage rate, $T_t(i)$ is a lump-sum transfer from the government and $\Pi_t(i)$ is the profit from the intermediate goods producers. Household i has access to state contingent claims, $B_{t+1}^C(i)$, implying that it can buy an asset for each state of the economy in the next period. These assets have the property that they yield one unit of Home currency in a particular state and zero otherwise. The total cost of buying these assets is $E_t Q_{t,t+1} B_{t+1}^C(i)$. Capital formation is subject to investment costs, $\Phi\left(\frac{x_t(i)}{k_{t-1}(i)}\right) k_{t-1}(i)$. I assume that $\Phi(\delta) = \Phi'(\delta) = 0$ and $\Phi''(\delta) = d$ where d is the investment adjustment cost. These restrictions ensure that the steady state is independent of the cost of adjusting investment.[23]

Since I assume complete within country risk sharing, only labor supplies and real wage rates will differ across households. Correspondingly, I drop index i in the following. The

[23] Because I solve the model by log-linearization, I do not have to specify a functional form for $\Phi(\cdot)$.

first order conditions are given as

$$
\begin{aligned}
1 &= \beta I_t E_t \left[\left(\frac{c_{t+1}}{c_t} \right)^{-\sigma} \frac{1}{\pi_{t+1}} \right] \\
\left(\frac{M_t}{P_t} \right)^{-1} &= (c_t)^{-\sigma} \frac{I_t - 1}{I_t} \\
(c_t)^{-\sigma} &= \kappa_t \left[1 - \Phi' \left(\frac{x_t}{k_{t-1}} \right) \right] \\
\kappa_t &= \beta E_t \left[(c_{t+1})^{-\sigma} r_{t+1} + \kappa_{t+1} \left(1 - \delta + \Phi' \left(\frac{x_{t+1}}{k_t} \right) \frac{x_{t+1}}{k_t} - \Phi \left(\frac{x_{t+1}}{k_t} \right) \right) \right]
\end{aligned}
$$

where I have defined $\frac{1}{E_t Q_{t,t+1}} = I_t$ as the Home nominal interest rate.

In the case of the single bond model, the households maximize utility subject to the following constraint

$$
\begin{aligned}
& P_t c_t (i) + P_t x_t (i) + B_t^I (i) + \frac{\varphi}{2} \left(B_t^I (i) - \bar{B} \right)^2 + M_t (i) \\
= \;& I_{t-1} B_{t-1}^I (i) + M_{t-1} (i) + P_t r_t k_{t-1} (i) + W_t (i) h_t (i) + T_t (i) + \Pi_t (i)
\end{aligned}
$$

and the capital accumulation constraint. Following Heathcote and Perri (2002), I introduce a small financial adjustment cost—indexed by φ—to induce stationarity. The first order conditions associated with this problem are the same as those under complete markets except for the consumption Euler equation which is given as (again leaving out index i because of complete domestic risk sharing)

$$
(c_t)^{-\sigma} \left(1 + \varphi B_t^I \right) = \beta I_t E_t \left[(c_{t+1})^{-\sigma} \frac{1}{\pi_{t+1}} \right]
$$

The financial autarky model is the same as the single bond model except that $B_t^I = \bar{B} = 0 \; \forall t$. In this case, the consumption Euler equation drops out as an equilibrium equation.

The Labor Union Sector. A union residing in Home solves

$$
\begin{aligned}
& \max_{W_t(i)} E_t \sum_{k=0}^{\infty} (\beta \psi)^k \left\{ \frac{(c_{t+k})^{1-\sigma}}{1-\sigma} - \frac{h_{t+k} (i)^{1+\phi}}{1+\phi} \right\} \\
& st. \; P_{t+k} c_{t+k} + P_{t+k} x_{t+k} + E_{t+k} Q_{t+k,t+k+1} A_{t+k+1} + M_{t+k} = \\
& A_{t+k} + M_{t+k-1} + P_{t+k} r_{t+k} k_{t+k-1} + W_t (i) h_{t+k} (i) + T_{t+k} + \Pi_{t+k} (i) \\
& h_{t+k} (i) = \left(\frac{W_t (i)}{W_{t+k}} \right)^{-\tau} h_{t+k}
\end{aligned}
$$

Because of complete domestic financial markets, only the wage and labor supply is household specific. Correspondingly, I do not index the remaining variables. The solution is similar under the alternative international financial market structures, as long as the domestic financial market offers complete within country consumption insurance. The first order condition associated with the problem is given as

$$E_t \sum_{k=0}^{\infty} (\beta\psi)^k \left[\begin{array}{c} (1-\tau)(c_{t+k})^{-\sigma} W_t(i)^{-\tau} (P_{t+k})^{-1} (W_{t+k})^{\tau} h_{t+k} + \\ \tau h_{t+k}(i)^{\phi} W_t(i)^{-\tau-1} (W_{t+k})^{\tau} h_{t+k} \end{array} \right] = 0$$

Solving for $W_t(i)$ yields

$$W_t(i) = \frac{\tau}{\tau-1} \frac{E_t \sum_{k=0}^{\infty} (\beta\psi)^k (h_{t+k}(i))^{\phi} (W_t)^{\tau} h_{t+k}}{E_t \sum_{k=0}^{\infty} (\beta\psi)^k (c_{t+k})^{-\sigma} (P_{t+k})^{-1} (W_t)^{\tau} h_{t+k}}$$

Final Goods Sector. A continuum of final goods producers exists in each country. They acquire intermediate goods from Home and Foreign producers, which they combine into a country specific final good. The final good is used for either consumption or investment purposes and is sold on a competitive market. The production function is

$$y_t = \left[\zeta^{\frac{1}{\theta}} (y_{H,t})^{\frac{\theta-1}{\theta}} + (1-\zeta)^{\frac{1}{\theta}} (y_{F,t})^{\frac{\theta-1}{\theta}} \right]^{\frac{\theta}{\theta-1}}$$

where $y_{H,t}$ and $y_{F,t}$ are aggregates of intermediate goods from Home and Foreign. These aggregates are given as

$$y_{H,t} = \left[\int_0^1 y_{H,t}(i)^{\frac{\omega-1}{\omega}} di \right]^{\frac{\omega}{\omega-1}}$$

$$y_{F,t} = \left[\int_0^1 y_{F,t}(i)^{\frac{\omega-1}{\omega}} di \right]^{\frac{\omega}{\omega-1}}$$

The problem of final goods producers falls in two steps. First, they decide upon optimal intermediate goods demand by

$$\min_{\{y_{H,t}(i)\}_{i=0}^{1}} \int_0^1 P_{H,t}(i)\, y_{H,t}(i)\, di$$

$$st.\ y_{H,t} = \left[\int_0^1 y_{H,t}(i)^{\frac{\omega-1}{\omega}} di \right]^{\frac{\omega}{\omega-1}}$$

which implies

$$y_{H,t}(i) = \left(\frac{P_{H,t}(i)}{P_{H,t}} \right)^{-\omega} y_{H,t}$$

with associated price index

$$P_{H,t} = \left[\int_0^1 P_{H,t}(i)^{1-\omega} di \right]^{\frac{1}{1-\omega}}$$

Second, they maximize profits subject to the production function

$$\max_{y_H, y_F} P_t y_t - P_{H,t} y_{H,t} - P_{F,t} y_{F,t}$$
$$st.\ y_t = \left[\zeta^{\frac{1}{\theta}} (y_{H,t})^{\frac{\theta-1}{\theta}} + (1-\zeta)^{\frac{1}{\theta}} (y_{F,t})^{\frac{\theta-1}{\theta}} \right]^{\frac{\theta}{\theta-1}}$$

The demand relations are given as

$$y_{H,t} = \zeta \left(\frac{P_{H,t}}{P_t} \right)^{-\theta} y_t$$
$$y_{F,t} = (1-\zeta) \left(\frac{P_{F,t}}{P_t} \right)^{-\theta} y_t$$

The associated price index is

$$P_t = \left[\zeta (P_{H,t})^{1-\theta} + (1-\zeta)(P_{F,t})^{1-\theta} \right]^{\frac{1}{1-\theta}}$$

which is the Home CPI as shown in the main text. An identical problem applies to final goods producers located in Foreign.

Intermediate Goods Sector. Producers use local currency pricing (LCP) and solve the following problem

$$\max_{P_{H,t}(i), P^*_{H,t}(i)} E_t \sum_{k=0}^{\infty} (\beta\gamma)^k \left\{ \frac{\Lambda_{t+k}}{\Lambda_t} \left[\begin{array}{c} P_{H,t}(i)\, y_{H,t+k}(i) + S_{t+k} P^*_{H,t}(i)\, y^*_{H,t+k}(i) \\ -P_{t+k} mc_{t+k} \left(y_{H,t+k}(i) + y^*_{H,t+k}(i) \right) \end{array} \right] \right\}$$
$$st.\ y_{H,t+k}(i) = \zeta \left(\frac{P_{H,t}(i)}{P_{H,t+k}} \right)^{-\omega} \left(\frac{P_{H,t+k}}{P_{t+k}} \right)^{-\theta} y_{t+k}$$
$$y^*_{H,t+k}(i) = (1-\zeta) \left(\frac{P^*_{H,t+k}(i)}{P^*_{H,t+k}} \right)^{-\omega} \left(\frac{P^*_{H,t+k}}{P^*_{t+k}} \right)^{-\theta} y^*_{t+k}$$

where $P_{H,t}(i)$ is the price to the Home market and $P^*_{H,t}(i)$ is the price in Foreign currency.

The optimal price $P_{H,t}(i)$ satisfies

$$E_t \sum_{k=0}^{\infty} (\beta\gamma)^k \frac{\Lambda_{t+k}}{\Lambda_t} \left[(1-\omega) P_{H,t}(i)^{-\omega} D_{H,t+k} + \omega P_{H,t}(i)^{-\omega-1} P_{t+k} mc_{t+k} D_{H,t+k} \right] = 0$$

where

$$D_{H,t+k} = \zeta (P_{H,t+k})^{\omega-\theta} (P_{t+k})^{\theta} y_{t+k}$$

Solving for $P_{H,t}(i)$ yields

$$P_{H,t}(i) = \frac{\omega E_t \sum_{k=t}^{\infty} (\beta\gamma)^k \Lambda_{t+k} P_{t+k} mc_{t+k} D_{H,t+k}}{(\omega-1) E_t \sum_{k=t}^{\infty} (\beta\gamma)^k \Lambda_{t+k} D_{H,t+k}}$$

Similarly, the first order condition for $P^*_{H,t}(i)$ is

$$E_t \sum_{k=0}^{\infty} (\beta\gamma)^k \frac{\Lambda_{t+k}}{\Lambda_t} \left[(1-\omega) P^*_{H,t}(i)^{-\omega} S_{t+k} D^*_{H,t+k} + \omega P^*_{H,t}(i)^{-\omega-1} P_{t+k} mc_{t+k} D^*_{H,t+k}\right] = 0$$

where

$$D^*_{H,t+k} = (1-\zeta)\left(P^*_{H,t+k}\right)^{\omega-\theta}\left(P^*_{t+k}\right)^{\theta} y^*_{t+k}$$

The optimal price can then be written as

$$P^*_{H,t}(i) = \frac{\omega E_t \sum_{k=t}^{\infty} (\beta\gamma)^k \Lambda_{t+k} P_{t+k} mc_{t+k} D^*_{H,t+k}}{(\omega-1) E_t \sum_{k=t}^{\infty} (\beta\gamma)^k \Lambda_{t+k} S_{t+k} D^*_{H,t+k}}$$

Because of constant returns to scale, optimal demand for labor and capital are found by minimizing cost subject to a certain output level.

$$\begin{aligned} &\min r_t k_{t-1} + w_t h_t \\ &st.\ \ (k_{t-1})^{\alpha} (h_t)^{1-\alpha} = \bar{y} \end{aligned}$$

This yields

$$\begin{aligned} r_t &= mc_t \alpha (k_{t-1})^{\alpha-1} (h_t)^{1-\alpha} \\ w_t &= mc_t (1-\alpha) (k_{t-1})^{\alpha} (h_t)^{-\alpha} \end{aligned}$$

where mc_t is marginal costs.

Money Supply. I assume that nominal money supply follows a stochastic process—see below. The proceeds from seigniorage are transferred back to households in a lump-sum fashion. I assume that the budget is balanced on a period by period basis so public transfers satisfy

$$M_t - M_{t-1} = T_t$$

where T_t is aggregate nominal lump-sum transfers.

Market Clearing Conditions and Solution Procedure. The final goods market clearing constraint in Home is given as

$$y_t = c_t + x_t + \Phi\left(\frac{x_t}{k_{t-1}}\right) k_{t-1}$$

In the single bond model, financial adjustment costs are added to the market clearing condition. Because they are quadratic, these costs do not have first order effects and will therefore cancel under my solution procedure. The same applies for investment adjustment costs.

The intermediate goods market constraint is given by

$$A_t (k_{t-1})^{\alpha} (h_t)^{1-\alpha} = \zeta \left(\frac{PA_{H,t}}{P_{H,t}}\right)^{-\omega} \left(\frac{P_{H,t}}{P_t}\right)^{-\theta} y_t + (1-\zeta)\left(\frac{PA^*_{H,t}}{P^*_{H,t}}\right)^{-\omega}\left(\frac{P^*_{H,t}}{P^*_t}\right)^{-\theta} y^*_t$$

The terms involving the PA indices reflect price dispersion and have no consequence for first order dynamics. They are therefore irrelevant under my solution procedure.

The closing of the model can vary a bit depending on the structure of financial markets. Under complete markets, the model is closed by the optimal risk sharing condition that states

$$q_t = \left(\frac{c_t^*}{c_t}\right)^{-\sigma}$$

where q_t is the real exchange rate. Under single bonds and financial autarky situations, the model is closed by imposing the representative Home household's flow budget constraint.

I solve the model by log-linearizing the equilibrium conditions around the non-stochastic steady state and solve the (now) linear dynamic system of equations using methods based on Blanchard and Kahn (1980).[24] As mentioned, I assume complete symmetry across countries, which implies that in steady state the current account is zero.

Calibration. I calibrate the benchmark (IRBC) model as follows

Table A1: Benchmark Calibration	
Preferences	
Discount factor	$\beta = 0.99$
Risk Aversion	$\sigma = 2$
Inverse Frisch Elasticity	$\phi = 2$
Financial adjustment cost	$\varphi = 10^{-3}$
Depreciation	$\delta = 0.025$
Final Goods Sector	
Home Bias	$\zeta = 0.85$
Elasticity of Substitution	$\theta = 1.5$
Intermediate Goods Sector	
Elasticity of Substitution	$\omega = 10000$
Nominal Rigidity	$\gamma = 0$
Labor Union Sector	
Elasticity of Substitution	$\tau = 10000$
Nominal Rigidity	$\psi = 0$

The new Keynesian model uses the same parameter values but sets $\omega = \tau = 11$ and $\gamma = \psi = 0.75$.

Across all experiments, the investment adjustment costs are set such that the volatility of HP-filtered investment relative to GDP in the single bond or financial autarky model (depending on the modeling of financial integration) in the quarterly data equals 2.78.[25] Chari, Kehoe and McGrattan (2002) calculate this value based on post-war US data.

[24] More precisely, I use Dynare to calculate the equilibrium law of motion.

[25] If investment is not sufficiently volatile, I set $d = 0$.

Shocks. There are two shocks in each country, a productivity and a money supply shock. Productivity shocks follow

$$\begin{bmatrix}\log(A_t)\\ \log(A_t^*)\end{bmatrix} = \begin{bmatrix}\rho^A & \varpi^A\\ \varpi^A & \rho^A\end{bmatrix}\begin{bmatrix}\log(A_{t-1})\\ \log\left(A_{t-1}^*\right)\end{bmatrix} + \begin{bmatrix}\varepsilon_t^A\\ \varepsilon_t^{*A}\end{bmatrix}$$

where I allow for correlation of the innovations. To estimate the parameters, I measure productivity using the production function[26]

$$\log(A_t) = \log(y_t) - (1-\alpha)\log(h_t)$$

Using the calibrated value of α, productivity is derived using data on GDP and labor input.[27] Results from estimating the VAR are $\rho^A = 0.964, \varpi^A = 0.035, corr\left(\varepsilon_t^A, \varepsilon_t^{*A}\right) = 0.1731, \sigma\left(\varepsilon_t^A\right) = 0.0065$. These estimates are close to those obtained by Heathcote and Perri (2002).[28]

Following Chari, Kehoe and McGrattan (2002) I assume that the growth rate of money $\mu_t = \log\left(\frac{M_t}{M_{t-1}}\right)$ follows the VAR

$$\begin{bmatrix}\mu_t\\ \mu_t^*\end{bmatrix} = \begin{bmatrix}\rho^\mu & \varpi^\mu\\ \varpi^\mu & \rho^\mu\end{bmatrix}\begin{bmatrix}\mu_{t-1}\\ \mu_{t-1}^*\end{bmatrix} + \begin{bmatrix}\varepsilon_t^\mu\\ \varepsilon_t^{*\mu}\end{bmatrix}$$

Again I rely on data from the US and Europe to estimate the parameters. However, given that many European countries were in an exchange rate regime with the US until 1971, and after that in more or less explicit regimes with Germany as the leader, I consider only the money supplies of the US and Germany. Using M1 as the measure of money supply, I get the following estimates: $\rho^M = 0.500, \varpi^M = 0.016, corr\left(\varepsilon_t^M, \varepsilon_t^{*M}\right) = 0.0108, \sigma\left(\varepsilon_t^M\right) = 0.01$.[29] These estimates are similar to those obtained by Kollmann (2001).[30]

[26]Following, for instance, Heathcote and Perri (2002) I neglect variations in capital input when calculating total factor productivity.

[27]I use data from the US and an aggregate of European countries. The countries are Germany, France, Italy and the United Kingdom in the period 1978q1 to 2002q3. See the data appendix for further descriptions of the data and empirical procedure.

[28]Heathcote and Perri (2002) obtain $\rho^A = 0.97, \varpi^A = 0.025, corr\left(\varepsilon_t^A, \varepsilon_t^{*A}\right) = 0.29, \sigma\left(\varepsilon_t^A\right) = 0.0073$.

[29]Neither the spill-over nor the correlation of innovations are significant at the 5% level, indicating that monetary policy was independent. However, in order to be consistent, I retain all parameters at their estimated value. See the data appendix for further descriptions of the data.

[30]Kollmann (2001) uses $\rho^M = 0.3, \varpi^M = 0, corr\left(\varepsilon_t^M, \varepsilon_t^{*M}\right) = 0.2, \sigma\left(\varepsilon_t^M\right) = 0.009$.

Table A2 collects the parameters of the stochastic processes.

Table A2: Benchmark Calibration, Stochastic Processes	
Productivity	
Persistence, productivity	$\rho^A = 0.964$
Spill-over, productivity	$\varpi^A = 0.035$
Std.dev. inno. productivity	$\sigma\left(\varepsilon_t^A\right) = 0.0065$
Correlation inno. productivity	$corr\left(\varepsilon_t^A, \varepsilon_t^{*A}\right) = 0.1731$
Money Supply	
Persistence, money	$\rho^M = 0.500$
Spill-over, money	$\varpi^M = 0.016$
Std.dev. inno. money	$\sigma\left(\varepsilon_t^M\right) = 0.0131$
Correlation inno. money	$corr\left(\varepsilon_t^M, \varepsilon_t^{*M}\right) = 0.0108$

Data.

Total Factor Productivity. I use GDP and labor supply data for the US, Germany, France, the United Kingdom and Italy for the period 1978q1 to 2002q3 obtained through Data-Stream. For GDP data I rely on the International Financial Statistics database published by the IMF. In particular, I use

- USI99BVRG (United States)
- BDI99BVRG (Germany)
- FRI99BVRG (France)
- UKI99BVRG (United Kingdom)
- ITI99BVRG (Italy)

The labor input data I use is from OECD's Main Economic Indicators. The mnemonics are

- USOEM040G (United States)
- BDOEM040G (Germany)
- FROEM040G (France)
- UKOEM040G (United Kingdom)
- ITOEM040G (Italy)

From this data I calculated a series for total factor productivity for each country using the production function

$$\log(A_t) = \log(y_t) - (1-\alpha)\log(h_t)$$

and the calibrated value of α. To get a European total factor productivity measure I aggregate productivity for each country using a weighted sum of log productivities. As country weights I use the average relative share of nominal GDP of the country over the sample period. Estimating the $VAR(1)$ on this data gave estimates

$$A = \begin{bmatrix} 0.9638168 & 0.0347618 \\ 0.0347618 & 0.9638168 \end{bmatrix}, \ \sigma = \begin{bmatrix} 0.006545 \\ 0.005184 \end{bmatrix}, \lambda = 0.1731$$

where symmetry was imposed in the estimation step. The first row corresponds to the US and where λ is the correlation coefficient between innovations. I used the standard deviation of the error in the US equation as the theoretical standard deviation of productivity innovations.

Money Supply. I obtain data for US and German money supply (M1, current prices) for the period 1971q1 to 1998q4. The data is from the international financial statistics compiled by the IMF and obtained using DataStream. The mnemonics are

- USQ59MACB (United States)
- BDQ59MACB (Germany)

Based on this data I calculated the growth rate of money for US and Germany using the relation

$$\mu_t = \log\left(\frac{M1_t}{M1_{t-1}}\right)$$

giving me two time series for money growth. Based on these series I estimate a $VAR(1)$ restricting the diagonal and off-diagonal parameters of the coefficient matrix to be equal. This gave the following estimates

$$A = \begin{bmatrix} 0.499828 & 0.0164096 \\ 0.0164096 & 0.499828 \end{bmatrix}, \ \sigma = \begin{bmatrix} 0.010403 \\ 0.015711 \end{bmatrix}, \lambda = 0.0108$$

where A is the coefficient matrix, σ contains the standard deviations of the errors in each equation and λ is the correlation between the errors. In the model, I use the standard deviation of the error in the US equations as the theoretical standard deviation of innovations.