Stock prices and GDP in the long run

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Abstract

Previous studies have documented long run equilibrium relationships between either stock prices and labour income or dividends and consumption. In a general equilibrium stochastic growth model, these variables are related in the long run because they are all driven by the same stochastic trend - the fundamental development of productivity. We show that national stock price indices are cointegrated with domestic and foreign GDP in the G7 countries. Higher domestic productivity increase both domestic GDP and domestic stock prices. In the panel, countries with favorable GDP developments also have higher stock prices. The relationship between relative GDP and relative stock prices is stronger for countries with markedly different GDP growth compared to their trading partners.

Keywords: Stock prices, Long Run Risks, Cointegration.
JEL classifications: E44, G12.

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1 Introduction

What determines the development of stock prices in the long run? According to the classic Lucas (1978) "tree model", the price of assets (fruit trees, in his model) is determined solely by the present value of future dividends (future fruit production). Hence, we expect a link between output and stock prices.

A theoretical relationship between stock prices and productivity within a country is derived in Kung and Schmid (2015), who construct a general equilibrium stochastic growth model with endogenous productivity growth and asset prices. Given that consumption, dividends, labour income, output, and stock prices are all endogenous variables driven by productivity, this model provides a potential theoretical explanation for long run equilibrium relationships between stock prices and labour income or consumption and dividends observed in the literature on long run asset price risk (Bansal and Yaron (2004), Benzoni et al., 2007). Gavazzoni and Santacreu (2015) develop a two country model where comovements in stock prices increase with trade in research and development. Colacito et al. (2014) show that the effects of productivity shocks on international capital flows may go in either direction depending on the utility function of households and whether the shock is temporary or permanent.

Empirically, the business cycle relationship between stock prices and output has been investigated thoroughly (Fama, 1981, Beaudry and Portier, 2006), but there is only a handful of studies of how these variables are related in the long run. Lettau and Ludvigson (2001) show that human and financial wealth are closely related in a wide class of asset pricing models. Their results imply that stock prices and labor income should be cointegrated, a finding that has indeed been empirically confirmed by Benzoni et

al. (2007). In a similar vein, several studies find a long run equilibrium or cointegrating relationship between consumption and dividends (Baxter and Iermann, 1997, Bansal and Yaron, 2004). In general equilibrium macroeconomic growth models, consumption, dividends, labor income, output, and stock prices are all endogenous variables driven by the stochastic productivity trend. The relationship between stock prices and output is in a sense more fundamental than the relationship between consumption and dividends since consumption is determined by output and dividends only constitute a part of the total return to equity investments[1].

Several studies document positive long run equilibrium relationships between domestic stock prices and domestic GDP. A first set of papers with cointegration include a number of macroeconomic variables in the long run equilibrium relationship with stock prices, but do not investigate whether stock prices are significant (this coefficient is *normalized* to unity). For instance, Cheung and Ng (1998) find cointegration between real stock returns and the real oil price, consumption, money balances and GDP. Nasseh and Strauss (2000) document cointegrating relationships between stock markets and domestic and German industrial production, short term interest rates, long term interest rates, CPI, and manufacturing order surveys in a number of European countries. Other similar studies include Chaudhuri and Smiles (2004) and Humpe and MacMillan, (2009). A second set of papers focus on U.S. data and report weak evidence of cointegration between GDP and stock prices. Rangvid (2006) finds that the ratio of stock prices to GDP is stationary, i.e. assumes that the cointegrating vector is [1, -1]. Cointegration is however rejected if appropriate critical values are used.[2] Hossain

[1] Most studies (including our paper) use data on stock prices that include re-invested dividends.

[2] The ADF test statistics in Rangvid (2006) is -2.56, which implies a rejection of the

and Hossain (2015) also reject cointegration between U.S. stock prices and GDP. Madsen et al. (2013) reject panel cointegration between stock prices and per capita output for 20 OECD countries using annual data and a very long sample period. Hassipis and Kalyvitis (2002) use a data set that is similar to ours, but only study the short run relationship between changes in stock prices and economic activity. Hence, there is little and/or ambiguous empirical evidence on the long run equilibrium relationship between stock prices and output.[3]

This paper studies the long run equilibrium relationship between stock prices, domestic GDP, and trade weighted foreign GDP for the G7 countries. The main contribution to the literature is that we include not only domestic but also (trade weighted) foreign GDP in the empirical model. Both the Lucas (1978) "tree" model and Kung and Schmid (2015) are closed economy models. The G7 countries are however open economies with exports plus imports accounting for 60 percent of GDP on average. The sign of the relationship between foreign GDP on domestic stock prices is not clear a priori. On one hand, we expect to find higher stock price growth in countries with high GDP growth than in countries with low GDP growth. That is, relative stock prices should be higher for countries with high relative GDP. On the other hand, domestic firms benefit not only from high domestic growth but also from high foreign growth (as in Gavazzoni and Santacreu, 2015). We investigate both these hypotheses.

Stock prices are cointegrated with domestic and foreign GDP in all G7

null hypothesis on no cointegration at the 10 percent significance level using standard critical values. The 10 percent critical value in MacKinnon is -3.046.

[3] There also is a sizable literature on how financial market development affect economic growth (see, for instance, Greenwood et al., 2013, and a series of papers by Levine), which is not directly related to the present paper.

countries. In contrast to previous cointegration studies of this issue, we test whether stock prices actually enters significantly into the cointegrating relationships (rather than normalize these coefficients to unity as is typically done). In case of the U.S., stock prices are not significant. Hence, our findings for the U.S. are consistent with previous studies (Rangvid, 2006, Hossain and Hossain, 2015). Stock prices are significant in the remaining cases and high domestic GDP is associated with high stock prices. Panel cointegration estimates imply that a productivity increase that leads to 2.88 percent higher GDP also increases stock prices by one percent.

The coefficients on foreign GDP have different signs for different countries and an insignificant coefficient in the panel tests. A natural hypothesis to test is whether domestic stock prices *relative* to foreign stock prices is affected by the development of domestic GDP relative to foreign GDP. We transform both stock prices and GDP into domestic relative to foreign variables. Relative GDP and relative stock prices are I(1) variables.They are cointegrated for the panel but not for the individual countries. An interesting observation from this part of the study is that there is a stronger positive relationship between relative GDP and relative stock prices for the countries that have experienced markedly different GDP developments compared to their trading partners. For instance, Japan grew much faster than the other OECD countries during the first part of the sample, and also had higher stock price growth. During the second part of the sample we observe the opposite: Japan's GDP growth has been virtually non-existent since 1990, and the Nikkei also fell behind other stock market indices. According to the panel cointegration tests, a positive domestic productivity shock that increases domestic GDP by 1.84 percent relative to foreign GDP also causes domestic stock prices to increase by one percent more than foreign stock

prices.

2 Data

Quarterly data on real stock market prices for the G7 countries are collected from the MSCI. These are inflation adjusted broad equity indices including re-invested dividends. Monthly data are converted to quarterly using the last observation of each quarter. The sample period is 1969Q1 to 2014Q4, where the starting date is dictated by the availability of the stock market data. Data on real GDP are volume indices from the OECD data base Main Economic Indicators, normalized to unity in 2010. Country specific foreign GDP is constructed as a weighted average of OECD 16 real GDP, using the OECD total competitive weights (TCW) of each country as weights.

Table 1 shows the correlations between stock prices and GDP as the horizon is increased from one quarter to 20 years. The contemporaneous correlation between quarterly changes in stock prices and quarterly changes in domestic GDP is only 0.06, while the correlation between 10-year changes in stock prices and 10-year changes in domestic GDP is 0.46. Hence, the relationship between the variables is much stronger in the long run than in the short run, which indicates that cointegration is a suitable tool for modelling this relationship.

Table 1: Correlations between stock prices and GDP at different horizons

Horizon, quarters	1	4	12	20	40	80
Domestic GDP	0.057	0.209	0.341	0.354	0.460	0.398
Foreign GDP	0.062	0.222	0.349	0.332	0.319	0.203
#Obs	1232	1211	1155	1099	959	679

Correlations between the i-quarter changes in stock prices and domestic/foreign GDP, where i-quarter changes are constructed as ln(x(t)) - ln(x(t-i)).

3 Empirical results

Cointegration between variables means that their stochastic trends are related and there exists a long run (stationary) equilibrium relationship. The Johansen (1988) cointegration procedure is multivariate and estimates the following VECM (Vector Error Correction) model:

$$\Delta X_t = \mu + \sum_{i=1}^{p} \Delta X_{t-i} + \Pi X_{t-1} + \varepsilon_t \qquad (1)$$

If the $X-$variables are cointegrated, the matrix Π has reduced rank and can be written as $\alpha\beta'$, where α is a reduced rank matrix containing the error correction parameters and β are the cointegrating vectors. μ is a vector of constants, p is the number of lags in the VAR, and ε_t are the reduced form residuals. Both the *trace* and the λ_{max} cointegration tests focus on the rank of the Π-matrix or the number of non-zero eigenvalues. The null hypothesis of the *trace* test is that all eigenvalues are equal to zero, while the null hypothesis of the λ_{max} test is that the largest eigenvalue is equal to zero. Both tests have a sequential testing procedure. First, if the null hypothesis of no cointegration is rejected, at least one eigenvalue is positive and there exists at least one cointegrating vector.[4] The null hypothesis that there is only one cointegrating vector is then tested against the alternative hypothesis that there are more than one cointegrating vectors. If cointegration is present, the cointegrating vectors can be estimated conditional on the cointegrating rank.

[4] If at least one cointegrating vector is found, the test procedure is repeated and the null hypothesis that at least one of the remaining eigenvalues is zero is investigated.

3.1 Stock prices and GDP

We first investigate the three-variable system containing domestic stock prices, domestic GDP, and foreign GDP. Table 2 shows the results from the cointegration tests. The number of lags is chosen according to the Schwartz information criterion and chosen sufficiently high to ensure that the residuals are not autocorrelated according to the Portmanteau and LM-tests. There is at least one cointegrating relationship in the trivariate VECM for all countries. A second cointegrating vector is indicated in the case of France.

Table 2: Cointegration tests

Country	$tr(1)$	$tr(2)$	$tr(3)$	$\lambda_{max}(1)$	$\lambda_{max}(2)$	$\lambda_{max}(3)$
Canada (2)	26.748	9.0586	2.052	17.690	7.007	2.051
Germany (4)	30.526	11.031	4.007	19.495	7.024	4.007
France (1)	37.477	14.555	2.179	22.922	12.376	2.179
Italy (4)	35.150	13.104	0.337	22.046	12.767	0.337
Japan (1)	35.187	9.782	1.764	25.405	8.0180	1.764
United Kingdom (1)	41.209	11.788	3.051	29.421	8.738	3.051
United States (2)	28.269	7.837	1.057	20.432	6.778	1.057
Critical values	26.79	13.33	2.69	18.60	12.07	2.69

The number of lags in the VAR is shown withing paretheses in the first column.
Critical values from Osterwald Lenum (1992).

Turning to the parameters in the long run equilibrium relationship, we expect a positive relationship between stock prices and GDP. As shown in Table 3, the coefficient on stock prices is positive in six out of seven cases, four of which are significant. The coefficients on foreign GDP have mixed sign We will return to this issue in Section 3.2. The parameters on stock prices are typically smaller than unity, implying that stock prices increase by less than one percent as GDP increases by one percent.

Taking a closer look at the U.S. case in Table 3, it is clear that stock prices enter the cointegrating vector with an insignificant coefficient. When

Table 3: Point estimates of cointegrating vectors

Country	*Domestic GDP*	*Foreign GDP*	*Stock prices*
Canada	1.00	-1.558	0.990
		[-2.567]	[4.239]
Germany	1.00	-1.776	0.781
		[-2.875]	[3.853]
France	1.00	0.9404	0.00
		[68.419]	
	1.00	0.00	0.195
			[13.095]
Italy	1.00	-0.117	1.053
		[-2.644]	[1.016]
Japan	1.00	0.498	0.188
		[7.793]	[6.630]
United Kingdom	1.00	0.216	-0.262
		[11.384]	[- 5.348]
United States	1.00	1.432	0.012
		[6.232]	[0.176]
Panel DOLS (1)	1.00	0.810	0.050
		[31.157]	[6.316]
Panel DOLS (2)	2.882	0.268	1.00
	[7.010]	[0.665]	

t-values within brackets.
The Fischer panel ADF test statistics for panel cointegration in Panel DOLS 1 (2) is -4.438 (-5.524) with a p-value of 0,000 (0.000).
The Im, Pesaran and Shin W-statistics is -1.525 (-2.611) with a p-value of 0.064 (0.005).

the cointegrating vector is normalized by assigning a unity coefficient to stock prices (as is typically done), the important hypothesis that stock prices enters the cointegrating relationship with a significant coefficient cannot be tested. With the current normalization, the interpretation of the coefficients is instead less intuitive. For the other six countries, the coefficients on stock prices are significant.

Figures 1a to 1g show stock prices, domestic GDP, and foreign GDP for the seven countries. Stock prices are much more volatile than the GDP series. In Japan, both real stock prices and domestic real GDP have remained virtually stationary since 1990. Another observation that we will return to

when studying relative GDP and relative stock returns is that the difference between domestic and foreign real GDP is relatively large for some countries (Japan, Italy, Germany, and the United States), while France and Canada have had approximately the same GDP developments as their trading partners.

Figure 1a: Stock prices, domestic GDP, and foreign GDP, Canada

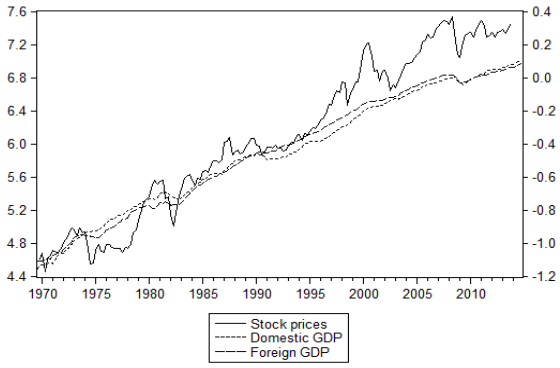


Figure 1b: Stock prices, domestic GDP, and foreign GDP, Germany

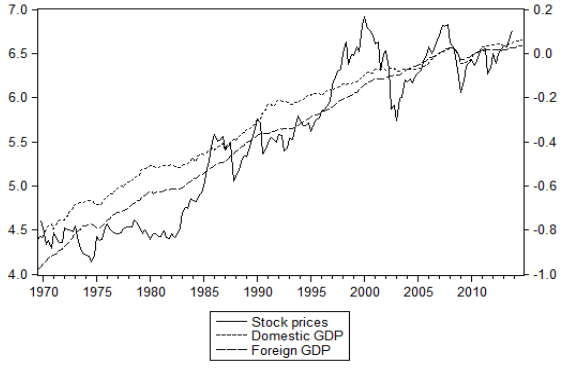


Figure 1c: Stock prices, domestic GDP, and foreign GDP, France

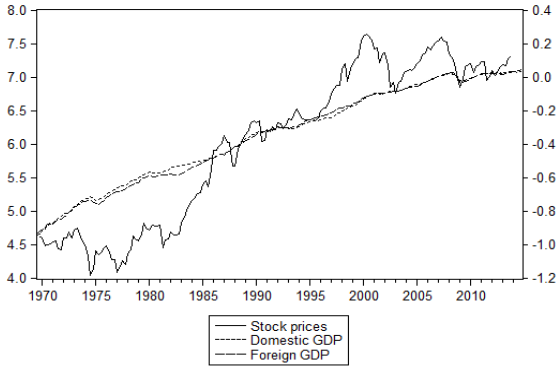
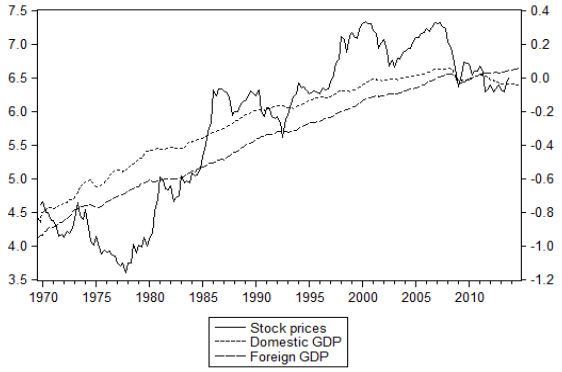
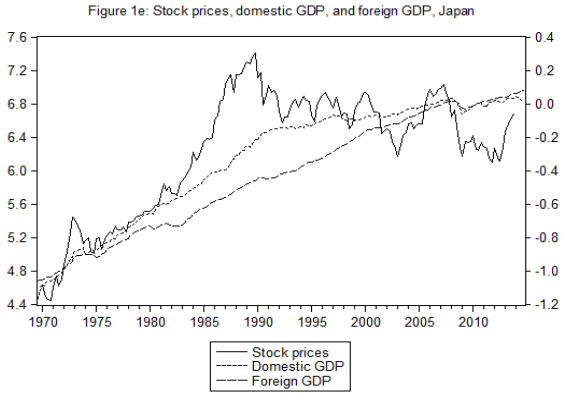
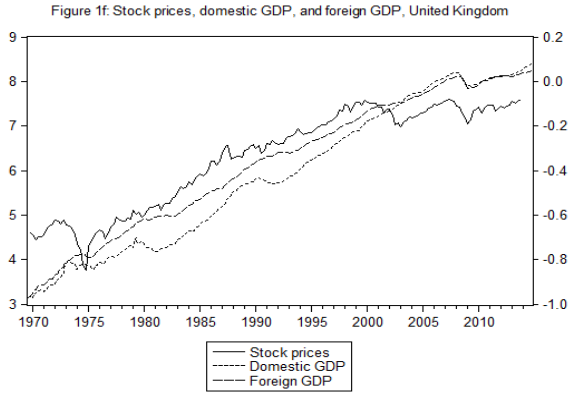
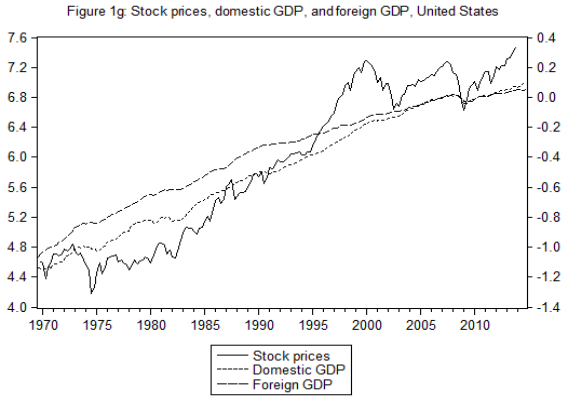


Figure 1d: Stock prices, domestic GDP, and foreign GDP, Italy









The Dynamic *OLS (DOLS)* panel cointegration estimates in the final row of Table 3 have the following implication: a productivity increase that leads to one percent higher stock prices is associated with 0.27 percent higher foreign output and 2.88 percent higher GDP. These are not causal relationships since all three variables are endogenous. The rows *DOLS (1)* and *DOLS (2)* show two different normalizations of the panel cointegrating vector, setting the coefficients first on domestic GDP and then on stock prices to unity. The hypothesis that stock prices are significant in the long run equilibrium relationship can only be tested when this coefficient is not set to unity, as

in *DOLS (1)*.[5] Panel unit root tests reported in the footnotes to Table 3 confirm that panel cointegration is present in the data.

3.2 Relative stock prices and relative GDP

While the relationship between domestic stock prices and domestic GDP appears to be reasonably straight forward, the three variable system studied in Section 3.1 delivers mixed evidence for the role of foreign GDP developments. An alternative hypothesis concerning the effects of higher foreign GDP on domestic stock prices is that countries with high GDP growth *relative to other countries* also have high relative stock price growth, again relative to other countries. In order to investigate whether this is the case, we transform both stock prices and GDP to relative variables (the ratio of domestic to foreign stock prices and GDP).

First, univariate Augmented Dickey-Fuller tests for unit roots on relative GDP and relative stock prices. The results in Table A1 in the Appendix indicate that all 14 time series contain unit roots. This means that domestic and foreign GDP are hence driven by different productivity trends, and domestic and foreign stock prices also contain different stochastic trends. Next, we investigate whether the stochastic trends in domestic versus foreign stock prices are in fact the same relative productivity trends manifest in relative GDP. Given that we only have two time series for each country (relative stock returns and relative GDP), only three outcomes from the cointegration tests are possible: no cointegration, one cointegrating relationship, and two cointegrating relationships The latter finding means that

[5] In theory, DOLS (1) and DOLS (2) should be renormalisations of the same vector if there is only one cointegrating vector. As these two vectors appear to differ, there are indications of a second cointegrating relationship.

both time series are (trend) stationary. The Johansen procedure rejects that relative stock prices and relative GDP are cointegrated for the individual G7 countries, see Table A2 in the Appendix[6]. We check the robustness of these cointegration results using a two step method.[7] Table 4 shows the Dynamic OLS estimator of the potential cointegrating vector, as well as the ADF unit root test on the residuals. Cointegration is still rejected for the individual countries. Several of the unit root test statistics are however below minus two. Given the low power of the ADF test to reject the null hypothesis of a unit root in small samples, the presence of panel cointegration in the final row of Table 4 is not surprising.

Two step cointegration procedures show the parameters of the potential long run equilibrium relationships together with the cointegration tests. We expect positive relationships between relative stock prices and relative GDP. As shown in Table 4, the coefficient on relative GDP is positive in five out of seven cases ADF tests in the final column however show that the residuals from the first step DOLS regression are not stationary. Individual country cointegration tests hence reject that there exist long run equilibrium relationships between relative GDP and relative stock prices. When comparing the point estimates in Table 4 with graphs of relative stock prices and relative GDP in Figures 2a through 2g, a potentially interesting pattern emerges. The countries that have experienced markedly different productivity developments compared to their trading partners display a positive relationship between relative stock prices and relative GDP: Japan, Italy,

[6] The results from the Johansen procedure are somewhat scattered as one cointegrating vector is found for Italy and two cointegrating vectors (implying that both series are stationary) are found in the case of Japan.

[7] Results from the Johansen procedure are placed in the Appendix and the two step DOLS results are in the main text because the latter method allows more information to be conveyed from a single table.

Table 4: Point estimates of cointegrating vectors

Country	*Relative GDP*	*ADF*
Canada	0.122	-2.567 (1)
	[7.869]	
Germany	2.415	-1.966 (1)
	[2.988]	
France	-9.078	-2.930 (0)
	[-4.460]	
Italy	1.419	-2.604 (2)
	[1.592]	
Japan	5.017	-2.247 (3)
	[7.132]	
United Kingdom	-0.328	-2.323 (4)
	[-0.441]	
United States	4.189	-2.255 (0)
	[9.122]	
Panel DOLS	1.840	-1.908
	[6.083]	{0.030}

t-values within brackets.
p-values withing curly brackets.
Number of lags in the ADF testw within parenthesis.
According to Engle and Yoo (1987), critical values for the ADF tests depends on the number of lags. For four lags, the five percent critical value is -3.25. Fewer lags gives lower critical values.

Germany, and the United States. In the case of France, domestic and foreign GDP are almost parallel in Figure 1c and the relationship between relative stock prices and relative GDP is negative. The U.K .is in between when it comes to differences between domestic and foreign GDP. If we had a larger panel of countries, this pattern could be explored further. Most of the countries appear to display a positive relationship between relative stock prices and relative GDP, even though the presence of cointegration between these two variables is formally rejected.

Figure 2a: Relative stock prices and relative GDP, Canada

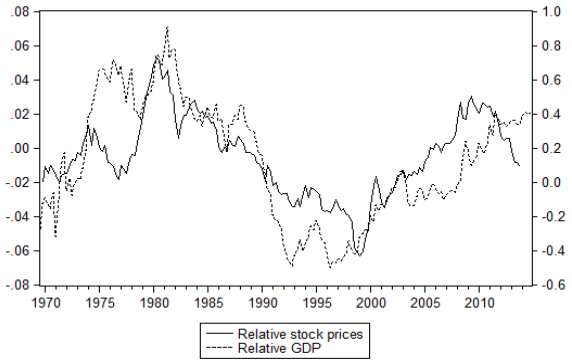


Figure 2b: Relative stock prices and relative GDP, Germany

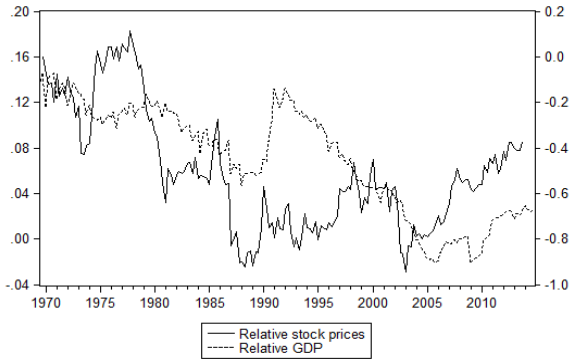


Figure 2c: Relative stock prices and relative GDP, France

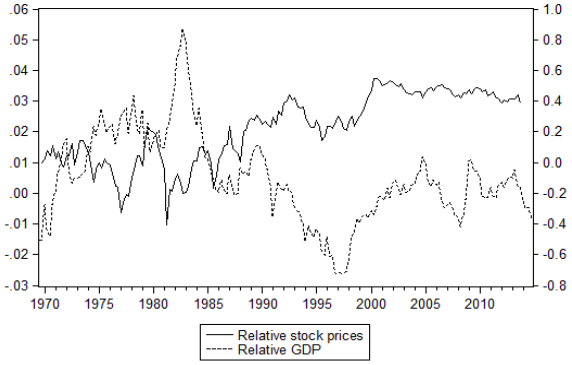


Figure 2d: Relative stock prices and relative GDP, Italy

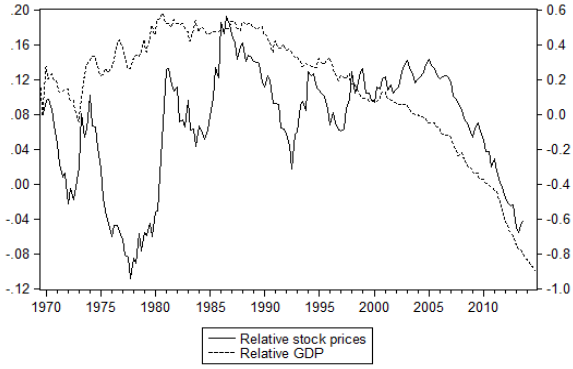


Figure 2e: Relative stock prices and relative GDP, Japan

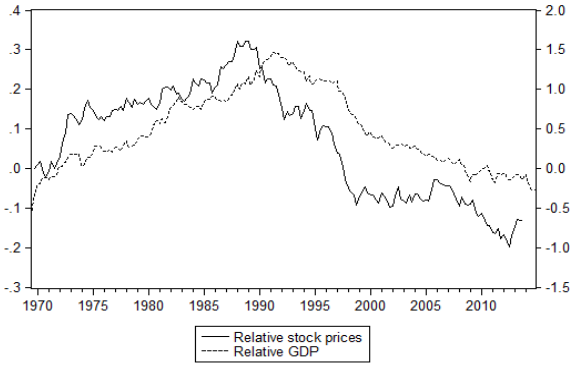


Figure 2f: Relative stock prices and relative GDP, United Kingdom

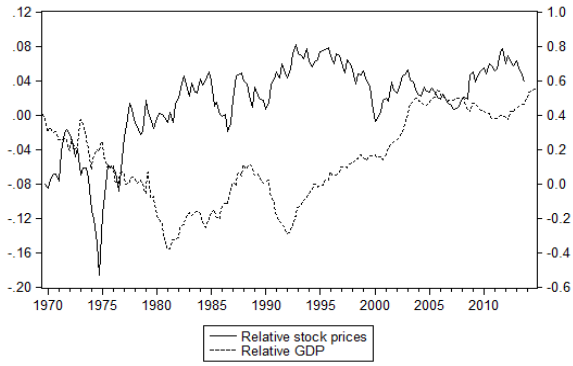
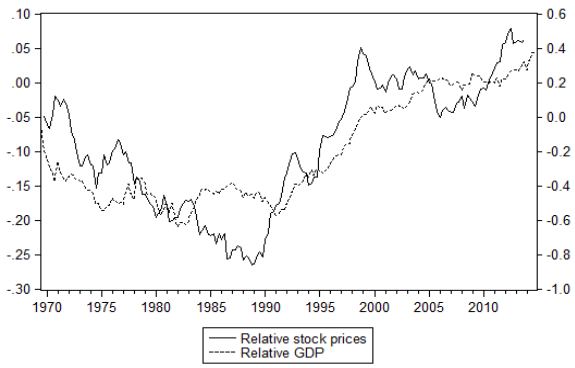


Figure 2g: Relative stock prices and relative GDP, United States



Panel cointegration tests in the final rows of Table 4 confirm that there is a positive equilibrium relationship between the relative development of stock prices and relative GDP *across* countries. A positive domestic productivity shock that causes domestic GDP to increases by 1 percent more than foreign GDP also causes domestic stock prices to increase by 1.84 percent more than foreign stock prices. Panel unit root tests reject the null hypothesis of a unit root in the residuals. This result is robust to other tests that allow individual unit root processes.

4 Conclusions

While the business cycle relationship between stock returns and GDP changes has been studied extensively (Fama, 1981, Beaudry and Portier, 2006, and others), the arguably more important long run relationship between the levels of GDP and stock prices remains relatively unexplored. There are theoretical reasons for expecting GDP and stock prices to be related in the long run. General equilibrium stochastic growth models where output, consumption, labor income, stock prices, and dividends are endogenous

variables driven by a common productivity trend imply that these variables should have long run equilibrium relationships or be cointegrated (see e.g. Kung and Schmid, 2015). Following Lettau and Ludvigson (2001), the partial equilibrium finance literature has explored the link between labor income, consumption and dividends at length (including several cointegration studies, e.g. Benzoni et al. (2007) and Bansal et al. (2009)). There are however only a handful of empirical studies focusing on the general equilibrium macroeconomic relationship between GDP and stock prices. Cheung and Ng (1988), Nasseh and Strauss (2000), Humpe and Macmillan (2009) and others document cointegration between stock prices and a large set of macroeconomic variables including GDP. These papers do not investigate whether stock prices actually enters the cointegrating relationship with a significant coefficient as they normalize this coefficient to unity. Hossain and Hossain (2015) reject the existence of bivariate cointegration between stock prices and GDP for the United States, United Kingdom and Japan. However, they use a short data set and long time series are often required to detect long run equilibrium relationships.

We show that domestic stock prices are cointegrated with domestic and foreign GDP in all the G7 countries. However, in case of the U.S. stock prices do not enter significantly in the cointegrating relationship. The remaining six countries display a positive, significant relationship between stock prices and domestic GDP. The point estimates imply that one percent higher stock prices is associated with more than one percent higher GDP. The average coefficient in the tri-variate Johansen models where stock prices are significant in the long run equilibrium relationships imply that GDP increases by 2.37 percent as stock prices increase by one percent. Since all variables are endogenous, these coefficients do not capture not causal effects between the

variables. Instead, a productivity increase that leads to one percent higher stock prices also increases GDP by more than two percent. A proper cointegrated panel estimated using dynamic OLS provides a (significant) point estimate of 2.88 for this coefficient.

The relationship between domestic stock prices and foreign GDP growth is not clear a priori given that the stochastic growth models with endogenous stock prices discussed above are closed economy models. Domestic firms operate abroad and could thereby benefit from foreign productivity developments. Only half of the countries display a significantly positive relationship between domestic stock prices and foreign GDP. Panel estimation yields a positive, insignificant coefficient. This lead us to investigating the role of foreign GDP further by transforming both stock prices and GDP to relative variables (the ratio of domestic to foreign stock prices or GDP), assuming that countries with high relative GDP also have high relative stock prices. We do not find long run equilibrium relationships between relative GDP and relative stock prices for the individual G7 countries. Panel cointegration tests indicate that relative stock prices and relative GDP are cointegrated. The coefficient implies that domestic stock prices increase by 1.84 percent more than foreign stock prices as domestic GDP increases one percent more than foreign GDP. A potentially interesting pattern emerges from the graphs of relative stock prices and relative GDP. The countries that have experienced markedly *different* GDP developments compared to their trading partners often show a positive relationship between relative stock prices and relative GDP. For instance, Japan grew much faster than its trading partners in the 1970s and much slower from the 1990s. Japanese stock prices relative to a trade weighted average of foreign stock prices mirror this development. U.S. relative GDP levels and relative stock price levels

also follow each other closely. A broader panel including more countries would be required to investigate this idea more thoroughly. Overall, our results provide more evidence of long run equilibrium relationships between stock prices and output than what is typically found.

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Appendix

Table A1: ADF tests for unit roots, relative stock prices and relative GDP

Country	*Relative stock prices*	*relative GDP*
Canada	-0.539 (0)	-0.945 (1)
Germany	-1.635 (4)	-2.296 (0)
France	-2.165 (0)	-1.942 (0)
Italy	2.257 (2)	-2.323 (2)
Japan	-0.622 (3)	-0.315 (0)
United Kingdom	-0.707 (0)	-2.564 (2)
United States	0.530 (0)	-0.426 (1)
Critical value	-2.877	-2.877

Parenthesis denote the number of lags.

Table A2: Cointegration tests

Country	$tr(1)$	$tr(2)$	$\lambda_{max}(1)$	$\lambda_{max}(2)$
Canada (2)	11.961	1.999	9.961	1.999
Germany (4)	7.078	2.803	4.275	2.803
France (1)	11.850	2.186	9.664	2.186
Italy (4)	16.153	1.062	15.091	1.062
Japan (1)	24.961	4.370	20.591	4.370
United Kingdom (1)	12.476	0.925	11.550	0.926
United States (2)	8.297	0.450	7.8476	0.450
Critical values	13.33	2.69	12.07	2.69

The number of lags in the VAR is shown withing paretheses in the first column.
Critical values from Osterwald Lenum (1992).