No. 2001/12

Trade Flows and the International Business Cycle

Daniel Gross

Center for Financial Studies
an der Johann Wolfgang Goethe-Universität ▪ Taunusanlage 6 ▪ D-60329 Frankfurt am Main
Tel: (+49)069/242941-0 ▪ Fax: (+49)069/242941-77 ▪ E-Mail: ifk@ifk-cfs.de ▪ Internet: http://www.ifk-cfs.de

CFS Working Paper No. 2001/12

Trade Flows and the International Business Cycle

Daniel Gross*

First Draft, July 2001
Final Draft, November 2001

Abstract:
We investigate into the role of the trade channel as important determinant of a country's current account position and the degree of business cycle synchronization with the rest of the world by comparing the predictions of two types of DGE models. It is shown that the behavior of a country's external balance and the international transmission of shocks depends amongst other things on two factors: i) the magnitude of trade interdependence, ii) the degree of substitutability between importable and domestically-produced goods. Using time series data on bilateral trade flows, we estimate the magnitude of trade interdependence and the elasticity of substitution between importable and domestic goods for the G7 countries. Given these estimates, idiosyncratic supply shocks potentially induce changes in the current account and foreign output that vary in direction and magnitude across G7 countries. The relationship between the magnitude of foreign trade and the import substitutability with various correlation measures is examined empirically in a cross-sectional dimension.

JEL Classification: E32, F41

Keywords: Intratemporal Elasticity of Substitution, Bilateral Trade Flows, Current Account, DGE Models

* Daniel Gross, Department of Economics, Johann Wolfgang Goethe-Universität, Zeppelinallee 29, D-60325 Frankfurt/Main, Germany, Email: dgross@wiwi.uni-frankfurt.de.

1 Introduction

Prime stylized facts of international business cycle theory refer to the positive correlation in the cyclical components of important macroeconomic variables across countries. The co-movements in output, consumption and investment have prompted the notion of an international business cycle. Empirically, the existence of a common cycle across industrialized countries has been documented by Dellas (1986) and Gerlach (1988) amongst others.

When investigating into the forces behind the commonness in aggregate fluctuations, economic research seems to have pointed in two directions. One strand of the literature examines the idea of common exogenous shocks that affect economies simultaneously. Stockman (1990), Phillips (1991), Kwark (1999), Lumsdaine and Prasad (1999) and Gross (2001) provide evidence that global shocks account indeed for a significant fraction of the international business cycle. Whilst this approach emphasizes the coincidence of economic disturbances, the other strand of the literature - that has attracted considerably more attention - focuses on transmission in that country-specific shocks may be propagated abroad. Economic interdependencies such as trade in goods and services or capital account transactions may serve as channels through which disturbances spill over across countries. This line of research is often called the "locomotive" theory as disruptions or expansions in trade or financial liquidity flows may pull an economy into recessions or booms. Berk (1997) and Prasad and Gable (1999) document empirically the large interdependencies in trade across major industrialized countries and trading blocs. Cantor and Mark (1988) and Dellas and Canova (1993) analyze theoretically the transmission of economic fluctuations in goods and security markets. They find evidence that the cross-country output correlation tends to increase with the openness of an economy - measured as export or import ratio in domestic output. These findings are confirmed by Anderson, Kwark and Vahid (1999) in a similar study. Glick and Rose (1999) present empirical evidence suggesting that the trade flows were the primary channel through which the Asian currency crisis spread. In contrast, a two-country study by Schmitt-Grohé (1998) somewhat weakens the hypothesis of a "locomotive" theory. She demonstrates theoretically that trade interdependencies are insufficient to account for the observed output correlations between the US and Canada despite huge trade interdependencies[1]. In the same line, Selover (1999) finds little empirical evidence for the transmission of economic

[1] For example, Canadian exports to the US represent about 5 percent of Canadian GDP and amount to roughly 75 percent of total Canadian exports. The imports figures are quite similar.

fluctuations neither across the major trading blocs North America, Japan-East Asia and Europe nor amongst the ASEAN countries. The absence of stringent empirical support for the "locomotive" hypothesis made Jensen and Selover (2000) suggest a non-linear relationship between trade interdependencies and business cycle transmission that they called "mode-locking". The term is used to characterize a process in which two weakly coupled systems tend to synchronize over time. Their simulation study suggests that trade in goods and capital are the types of weak linkages important for business cycle synchronization but that the transmission of shocks occurs in a non-linear fashion.

Complementary studies shifted their focus away from the magnitude of trade interaction to the necessity of trade interaction. Research along these lines triggered the question: How dependent are economies from importable goods? The parameter that captures an economy's dependency upon importable goods is known as the elasticity of substitution between importable and domestically-produced goods. This parameter is also known as the intratemporal elasticity of substitution (IES) or the price elasticity of export and import demand[2]. The intratemporal elasticity of substitution (IES) is of equal importance to trade theory and international business cycle theory which explains why studies along these lines often combine both branches of macroeconomic research. The famous Marshall-Lerner-Robinson condition[3] serves as centerpiece that provides the most common link between trade theory and international macroeconomics. The condition refers to the relative size of import and export demand elasticities. Goldstein and Kahn (1985) and Hooper and Marquez (1995) survey the empirical literature for estimates of the IES. Although the Marshall-Lerner-Robinson condition applies to a static economy, some of its flavour carries over to intertemporal models that incorporate trade and relative prices. Building on earlier work by Obstfeld (1982) and Svensson and Razin (1983), Backus, Kehoe and Kydland (1994a and b) study the implication of the IES for the behavior of the trade balance and the terms of trade in a dynamic general equilibrium (DEG) model. Cashin and McDermott (2000) discuss the implications of high and low intratemporal consumption elasticities for the current account in the presence of terms of trade shocks. In a sensitivity analysis, Kollmann (1999) varies over the intratemporal elasticity of substitution to demonstrate the impact on the cross-country output correlation. Tille (2001)

[2] The term price elasticity is preponderantly used in the trade literature whilst the business cycle terminology preferably refers to the intratemporal elasticity of substitution. We will use these terms synonymously.

[3] The Marshall-Lerner-Robinson condition states: If the trade balance is initially zero, a currency depreciation causes a current account deficit if the sum of the import and export demand elasticities exceeds one.

analyzes the effect of different degrees of consumption substitutability within and across countries with respect to changes in output, the current account and economic welfare.

The present work is inspired by previous findings in Gross (2001). For the sample of the seven largest economies, country-specific shocks are analyzed with respect to the US. These shocks are found to exert a significant positive impact on domestic investment in all cases. In contrast, their impact on the current account has been insignificant in all cases except Canada which is puzzling at a first glance. A potential explanation of this empirical "puzzle" emphasizes the composition of Canada's trade balance. Exports from and imports to the US amount to more than three-quarters of total Canadian exports and imports suggesting that the magnitude and the dependence upon foreign trade are important determinants of a country's external balance. Because the current account reflect temporary changes in output, it seems likely that the trade channel also affects the co-movements of output across countries.

In this paper, we examine two factors that are believed to be the primary determinants for the transmission of economic disturbances across countries. In particular, the magnitude of trade interdependence and the elasticity of substitution between importable and domestic goods are analyzed with respect to their influence on the transmission of economic fluctuations. Using quarterly time series data on bilateral trade flows for the G7 countries, we test empirically the significance of trade interdependencies for cross-country output correlations and provide estimates for the IES. Our results confirm earlier studies by Dellas and Canova (1993) and Anderson, Kwark and Vahid (1999) that the cyclical movements in output become more synchronized the larger the volume of bilateral trade is. Point estimates of the IES vary substantially implying that country-specific shocks induce responses in a country's external balance that differ in magnitude and direction across the major industrialized economies.

This paper is organized as follows. In section 2, we summarize the stylized facts of international business cycle and trade theory. This set of stylized facts is intended to serve as point of reference when discussing the theoretical predictions of the models. In section 3, we present two open-economy models that differ in their assumptions concerning the market structure and price flexibility. We discuss theoretical predictions and empirical evidence concerning the magnitude of trade interdependence and output correlation in section 4. In section 5, we derive equations that allow us to estimate the elasticity of substitution between importable and domestically-produced goods. The implications of the point estimates are discussed with respect to cross-country output correlations and movements in the current account as predicted by theory. The main results and conclusions are summarized in section 6.

2 Stylized Facts

The objective of this section is to provide a comprehensive set of stylized facts that characterize the relationship between external trade and aggregate macroeconomic fluctuations across countries. For that purpose, we assemble data from the International Financial Statistics (IFS) and the Direction of Trade Statistics (DOTS) for the seven major industrialized countries (G7). We restrict our attention to the period from 1980 until 1999 since time series data on bilateral trade flows at an higher than annual frequency is only available from 1980 onward. A precise description of the data is given in appendix B. As is common practice in the literature, we begin by summarizing multilateral correlations and volatilities.

2.1 Volatility and Unconditional Correlations

In order to facilitate comparisons with previous work by Backus, Kehoe and Kydland (1994a and b), Fiorito and Kollintzas (1995), Baxter (1995), Zimmermann (1995), Razin (1995) and Prasad and Gable (1997), we adopt their methodology in generating the statistics. The Hodrick-Prescott (HP) filter is applied to all variables using a weighting parameter $\lambda = 1600$. Then, the unconditional moments are derived from the cyclical components of all variables. To gauge the principal relationship between economic fluctuations and external trade, we focus in particular on a measure of a country's economic activity, its output (GDP), the relative price of exports to imports, the terms of trade (ToT), a country's total external balance, Net Exports (NEX), and a measure of a country's external balance with the other G7 countries, that we will denote NEXG7. Although much of the open economy macroeconomics literature has identified the current account that qualifies most for reflecting a country's external balance, the present study's focus is on the net export balance. The reasons are threefold. The current account comprises both, trade flows and net factor incomes. Since we are interested in the transmission of economic fluctuations through trade, the net export balance appears to better suit our needs. Additionally, variations in the net export balance and the current account are highly correlated across major industrialized countries[4]. With the exception of Germany

[4]The high correlations in the short term variations of the current account and the trade balance have been noted previously by Baxter (1995) and Gable and Prasad (1997).

in the post-reunification period, the current account and the net export balance move on a one-to-one basis in the major industrialized countries. Figure A.1 in appendix A illustrates this empirical fact. The last reason refers to data availability. Bilateral data of the current account is not recorded statistically to the authors knowledge. Given the evidence above, bilateral net export balances reasonably approximate bilateral current accounts.

Departing from the standard definition of the terms of trade, we follow Backus, Kehoe and Kydland (1994a and b) and define the terms of trade as ratio of the import price deflator over the export price deflator. Export and import data within G7 countries is constructed by aggregating bilateral trade flows over the relevant trading partners. Another convention has to be adopted that refers to the unit in which nominal variables are denominated. Unless otherwise indicated, variables are denominated in national currency units using the period-average market exchange rate.

Table I summarizes the standard deviations and unconditional correlations of key variables for all G7 countries. Real output[5] and the terms of trade are in logarithms whilst trade variables are expressed as ratios to domestic GDP.

Volatilities and Unconditional Correlations

	Canada	France	Germany	Italy	Japan	UK	US
			Standard Deviations				
GDP	2.17	1.03	2.56	1.22	1.24	1.67	1.42
ToT	2.74	2.32	2.91	3.09	6.40	1.47	1.72
NEX	0.27	0.57	0.95	1.03	0.15	1.11	0.11
NEXG7	0.22	0.39	0.48	0.54	0.09	0.63	0.06
			Unconditional Correlations				
GDP - ToT	-0.38	-0.25	-0.05	-0.22	0.35	0.11	-0.06
GDP - NEX	-0.15	-0.22	-0.61	-0.17	-0.33	-0.32	-0.37
GDP - NEXG7	-0.04	-0.25	-0.58	-0.13	-0.25	-0.49	-0.24
ToT - NEX	-0.24	-0.05	-0.29	-0.17	-0.38	-0.10	-0.14
ToT - NEXG7	-0.20	0.16	-0.21	-0.06	0.08	-0.15	-0.08

Table I) Statistical properties of HP-filtered cyclical components

i) Statistics for trade variables have been computed as ratio to GDP (NEX/GDP)

The standard deviation measures the average quarterly percentage deviations of a variable from their trend. In the sample period, the average deviation of output from its

[5] A measure of real output is obtained dividing nominal gross domestic product by the consumer price deflator.

trend lies in the range of 1 - 2.5 percent across the G7 countries. The terms of trade have been more volatile than output and the deviations are in the range of 1.5 - 6.5 percent. The ratios of net exports to output are somewhat less variable than output with an average deviation usually below 1 percent. Without the normalization by nominal output, net export balances would be markedly more volatile than GDP and the terms of trade. Further, the consolidated net export balances that account only for trade within G7 countries (NEXG7) appear to be more stable than the external balances that reflect total net exports. More precisely, trade balances amongst the major economies are between 25 and 50 percent less volatile when compared to the variability in total net exports. This observation suggests that economic conditions are more stable amongst G7 countries than elsewhere. The lower part of table I summarizes the unconditional correlations between output, net exports and the terms of trade.
Total net exports and the terms of trade are negatively correlated in all countries although the coefficients are statistically significant for Canada, Germany and Japan only[6]. Focussing on net exports within G7 countries, we find a negative and significant correlation with the terms of trade only for Canada and Germany. Further, GDP and total net exports are negatively correlated in all G7 countries. The relationship is statistically significant except for Canada and Italy. This evidence carries over to the correlation between output and net exports within G7 countries. The evidence is more heterogeneous when analyzing the output - terms of trade correlation. We find a negative and significant relationship in Canada, France and Italy. For Germany and the US, the correlation coefficients are negative but insignificant. In Japan and the UK, output and the terms of trade are positively correlated but the coefficients are significant for Japan only. Despite some differences in magnitude, the stylized facts with respect to output, net exports and relative prices are relatively stable across the major industrialized countries. These observations confirm earlier studies including Backus, Kehoe and Kydland (1994a and b), Baxter (1995), Zimmermann (1995), Razin (1995) and Prasad and Gable (1997).

2.2 Net Exports and the Terms of Trade

Idiosyncratic shocks are supposed to induce relative changes in output and prices across countries. Movements in relative prices are likely to affect demand for exports and imports

[6] Under the null hypothesis that the true correlation coefficient is zero, the approximate standard error for all correlation coefficients in our sample is about 0.10. Then, correlations are statistically significant at conventional levels if the coefficients exceed 0.2 in absolute value.

and thus qualify as determinants of a country's external balance. If quantities cannot adjust instantaneously to changes in relative prices, the contemporaneous correlation between the terms of trade and net exports - as shown in table I - do not reveal important regularities that appear when the cross-correlation function at various leads and lags is examined. In order to capture the dynamic behavior of the trade balance, figure 2.1 displays the cross-correlation functions between the terms of trade ToT_t and total net exports NEX_{t+k} and net exports within G7 countries $NEXG7_{t+k}$ at various leads and lags k. For positive k, the correlations refer to current prices and future net exports.

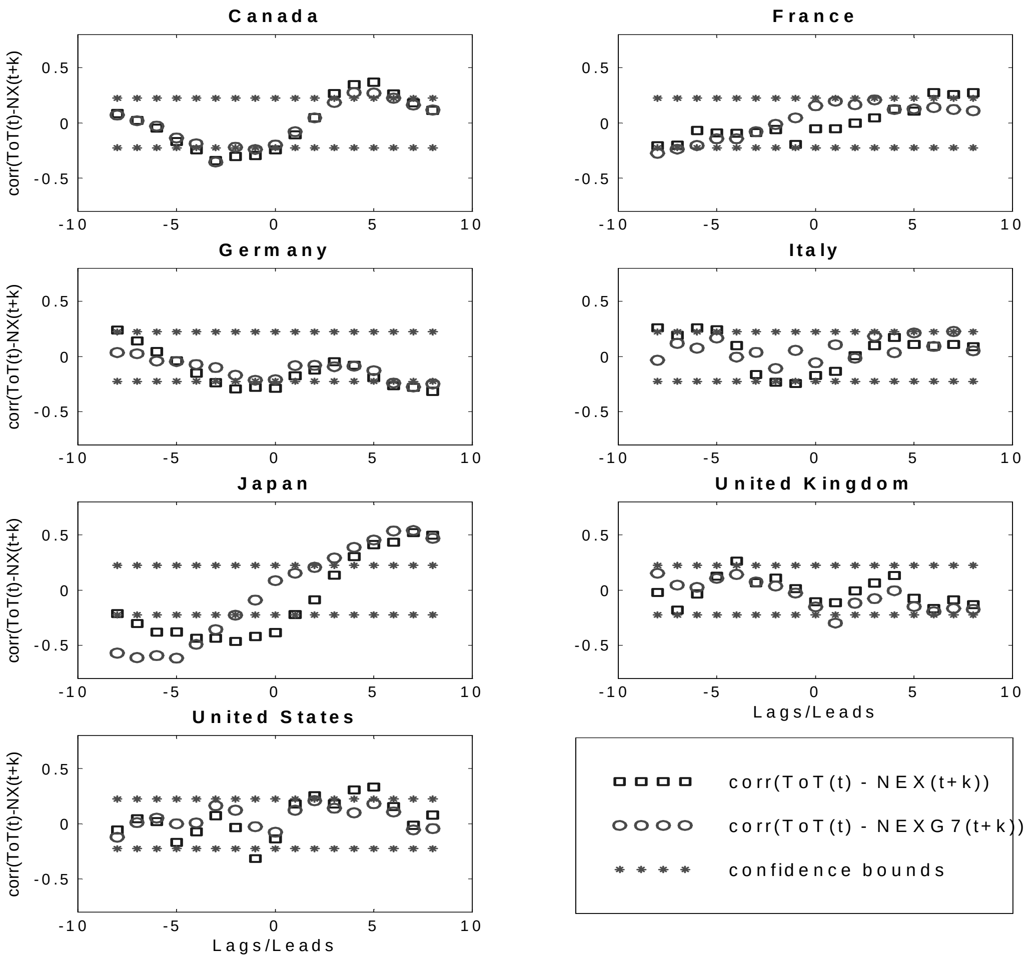

Figure 2.1: Cross-Correlation Function between Terms of Trade and Net Exports

We find that the cross-correlation functions have an asymmetric S-shape for Canada and Japan and to a lesser extend for France and Germany. This result is quite intuitive. A deterioration in the terms of trade improves a country's competitiveness as the price of imports increases relatively to the price of exports. As exports increase and imports diminish, a country's external balance moves into surplus. In this sense, the cross-correlation function indicates how responsive are movements in net exports to changes in relative prices. However, a closer look at figure 2.1 suggests that for any other country, no pronounced S-curve pattern can be detected. This observation is in contrast with an earlier study by Backus, Kehoe and Kydland (1994a) who found these S-curves in eight out of eleven OECD countries[7]. Additionally, with the exceptions of Canada and Japan, net exports do not appear to react significantly to relative price changes. The cross-correlation functions lie within the two-standard error confidence bounds at various leads and lags. Importantly, there is no evidence that net exports within G7 countries react to relative price changes differently than total net exports. Overall, the responsiveness of net exports to changes in relative prices is rather limited. However, the evidence in this point is somewhat sketchy.

2.3 Trade Interdependencies and Diversification

When analyzing trade flows as transmitters of business cycles, it is almost a prerequisite to characterize the size of trade flows and their diversification across countries. The ratio of imports and exports to GDP is a standard measure in the literature (see Canova and Dellas (1993) or Prasad and Gable (1997) amongst others) that indicates the magnitude of trade interdependencies. Table II summarizes the main stylized facts. Trade interdependencies are computed using total and G7 exports and imports.

Trade Interdependence

	Canada	France	Germany	Italy	Japan	UK	US
EXG7/GDP	5.68	8.57	9.20	8.42	1.17	8.17	0.83
EX/GDP	6.56	18.12	24.49	17.33	2.53	19.42	1.66
IMG7/GDP	4.70	8.88	8.39	8.18	0.65	10.17	1.12
IM/GDP	5.91	18.24	20.83	17.97	2.03	21.13	2.16

Table II) Mean export and import shares in GDP (in percent)

Trade appears to be particularly important for the European representatives in the group of G7 countries. Export and import shares in GDP are in the range of 20 to 25 percent.

[7]These authors examined quarterly OECD data for 11 countries including all G7 countries. The sample periods differed somewhat across countries depending on data availability, but ended all in 1990. Interestingly and in contrast to the present work, their cross-correlation functions turned out to be statistically significant in most cases.

The importance of foreign trade declines markedly for the remaining countries. Canadian exports and imports amount to less than 7 percent of GDP. The shares further decrease to below 3 percent for Japan and the US. The cases of Japan and the US reveal a general characteristic that large economies tend to be less open to foreign trade as noted by Bayoumi (1996). The importance of foreign trade amongst the major industrialized countries becomes apparent when comparing consolidated export (imports) within G7 countries with total exports (imports). Approximately 50 percent of all trade flows occur amongst the seven largest economies[8]. The import and export shares in GDP have been substantially volatile over the sample period as can be seen in figure A.2 in appendix A.

Direction of Trade Flows in G7 Countries

Countries		Canada	France	Germany	Italy	Japan	UK	US
Canada	EX		1.30	1.81	0.9	5.66	2.66	74.28
	IM		1.45	2.32	1.21	5.69	2.76	66.04
France	EX	0.92		17.66	10.91	2.01	8.71	7.22
	IM	0.71		18.30	10.60	3.44	7.56	8.35
Germany	EX	0.81	10.08		8.27	2.13	7.93	8.29
	IM	0.81	11.40		8.54	5.22	7.02	7.34
Italy	EX	0.99	13.76	17.04		2.05	6.46	8.78
	IM	0.76	13.62	18.87		2.03	5.28	5.55
Japan	EX	2.39	2.30	5.40	1.08		3.59	32.05
	IM	3.41	1.78	3.45	1.42		1.97	21.53
UK	EX	1.95	8.39	12.04	4.66	2.53		12.80
	IM	1.89	8.84	14.68	5.08	5.46		12.13
US	EX	20.36	4.07	5.50	2.10	12.05	5.77	
	IM	19.20	2.63	5.51	2.40	17.76	4.24	

Table III) Bilateral trade flows as ratios to total exports (imports) in percent

Importantly, the figure does not reveal a tendency that the volume of trade - as ratio to GDP - has distinctly increased over time in the major industrialized economies. This observation conflicts with a conclusion drawn in Gable and Prasad (1997) that the recent

[8] There are some outliers that should be mentioned. German exports to and Japanese imports from other G7 countries merely amount to one-third of their totals. Canada is the counter example. Trade with other G7 countries accounts for more than 80 percent of total Canadian trade.

decades witnessed rapid increases in the volume of trade for industrialized economies[9]. Another statistic that deserves attention is the direction of trade flows amongst the G7 countries. Table III reports the direction of bilateral exports (imports) as ratios to a country's total exports (imports). The figures are sample means. We will summarize the empirical content of these figures by addressing the question: Are trade flows sufficiently diversified, that is, do countries pool their risks from foreign trade? This questions points to the joint analysis of the direction and the level of foreign trade. There is a notable and important difference to the question if countries pool their risk by trading commodities and assets internationally. The latter question is generally answered with No. It is a wide held view that for most of the industrialized countries, the extent of foreign portfolio diversification is too low as it can be explained by standard models of financially integrated economies as shown amongst others by Cole (1988) and Cole and Obstfeld (1991). Under the assumption that idiosyncratic and common shocks are equally distributed across the sample countries[10], we tend to answer this question with a conditional yes, but there may be exceptions. In most cases, bilateral exports (imports) account for less than 10 percent of total exports (imports) and are roughly equally distributed across the sample pairs. However, there are prominent country-pairs like Canada-US, France-Germany, Italy-Germany and Japan-US where the relevant shares exceed 10 percent by far. In particular, if the US is subject to idiosyncratic shocks and if these shocks may be transmitted abroad through trade, it its likely that they will have a sizeable impact on the Canadian economy because Canada maintains 75 percent of its exports with the US. The directions of trade flows are also determined by other important factors that we disregard here. Geographical distances[11] or intra-industry trade are but two of a potentially much larger set of relevant variables. However, exploring the complete set of variables is beyond the scope of the present work.

[9]A closer look at their figures does not convincingly support their argument. Examining only G7 countries, their figures show a slight increase in the export-output ratio for the US and Canada. For any other country, the share of exports in GDP do not show any tendency, neither to grow nor to decline.

[10]By making this assumption, countries perfectly pool their risk from foreign trade, if trade flows are evenly distributed across trading partners. This idea is much like trading contingent claims in a two-country world. A perfect risk-pooling equilibria here requires that each country acquires contingent claims to half of the other countries output as show in Lucas (1982). In the real world, however, shocks may be country-specific in nature and unevenly distributed across countries which implies that risk pooling may necessitate a portfolio of contingent claims being unequally distributed across countries. See amongst others, Obstfeld and Rogoff (1996), chapter 5.

[11]New trade theorist emphasize amongst other forces the geographical distance between two countries. Krugman (1995) and gives a pleasant survey of the "New Trade Theory".

2.4 Bilateral Output and Net Export Correlations

The stylized facts - reported in tables I and II - refer to aggregate variables like a country's total net exports. It would be interesting to see if relationships are robust if the focus is narrowed down to a bilateral perspective. In particular, we are interested in the co-movements of output, relative prices and net exports on a bilateral basis. Unfortunately, data on bilateral relative prices are not available. Therefore, table IV only focuses on bilateral output correlations (corr(y-y*)) and the correlations between output and bilateral net exports (corr(y-bnex)). We begin by drawing attention to bilateral output correlations. A major stylized fact of international business cycle theory states that output is strongly positive correlated across countries as documented in Backus, Kehoe and Kydland (1994a and b) and Baxter (1995).

Unconditional Correlations on a Bilateral Basis

Countries		Canada	France	Germany	Italy	Japan	UK	US
Canada	corr (y-y*)		0.17	-0.45	0.21	0.06	0.66	0.77
	corr (y-bnex)		0.03	-0.28	-0.13	0.26	-0.01	-0.09
France	corr (y-y*)	0.17		0.04	0.65	0.15	0.33	0.11
	corr (y-bnex)	-0.03		-0.17	-0.20	0.04	0.21	-0.32
Germany	corr (y-y*)	-0.45	0.04		0.27	0.14	-0.36	-0.18
	corr (y-bnex)	-0.10	-0.42		-0.31	-0.48	-0.52	-0.06
Italy	corr (y-y*)	0.21	0.65	0.27		0.49	0.23	0.16
	corr (y-bnex)	-0.25	0.01	-0.04		0.13	0.09	-0.39
Japan	corr (y-y*)	0.06	0.15	0.14	0.49		0.13	0.01
	corr (y-bnex)	-0.08	-0.11	-0.04	-0.26		-0.11	-0.22
UK	corr (y-y*)	0.66	0.33	-0.36	0.23	0.13		0.57
	corr (y-bnex)	-0.01	-0.19	-0.51	-0.24	-0.11		-0.22
US	corr (y-y*)	0.77	0.11	-0.18	0.16	0.01	0.57	
	corr (y-bnex)	0.12	-0.33	-0.28	-0.37	-0.31	0.16	

Table IV) Bilateral correlations of hp-filtered output and net-export components; corr(y-y*) and corr(y-bnex) refer to bilateral correlations between output and output and net exports respectively

Our sample statistic is somewhat scant in this regard. On the one hand, we detect positive cross-country output correlations between Canada-US, Canada-UK, France-Italy, France-UK and Italy-Japan that are in the range of earlier studies. On the other hand, there are other countries pairs where changes in output appear to be hardly correlated across countries at all[12]. Even more extreme, cyclical movements in output are inversely related for the country-pairs Germany-Canada, Germany-UK and Germany-US. The average output correlation amongst G7 countries is 0.20, a figure that is much lower than reported in previous studies[13]. Even if Germany is excluded from the sample[14], the average output correlation would still be markedly lower (0.29) than comparable benchmark values. Notwithstanding the German experience, bilateral output correlations vary considerably across the major industrialized countries. Next, consider the relationship between output and bilateral net exports. Recall, total net exports and output proved to be statistically significant and inversely related for aggregate variables. On a bilateral basis, output and net exports are negatively correlated in 34 out of 42 sample observations whom of which 18 are statistically significant. In only 2 cases, the coefficients are positive and statistically significant. We find no statistically significant correlation between bilateral net exports and real GDP in 22 out of 42 sample pairs. Although these observations cannot question the general validity of the stylized facts, they nevertheless suggest that bilateral correlations may differ in terms of size and sign across countries. Economic theory knows a variety of factors that determine the dynamics of the a country's external balance and international co-movements of output. Given the evidence here, these factors deserve more attention when explaining cross-country differences. In section 3 and 4, we will examine two of them in more depth.

3 Open Economy Models

Why invoke two models in order to discuss the key determinants of the trade channel? The answer is simple and straightforward. Because, they give different answers to the same question. And yet, it is by no means clear if major industrialized economies are adequately characterized by monopolistic producers who determine market prices or by perfectly competitive product markets where prices flexibly adjust to clear markets. Although the models in question differ in such central features like the determination of prices and

[12] Prominent examples are Canada-Japan, France-US, Germany-France or Japan-US.

[13] Kollmann (1999) reports an average output correlation of 0.61 amongst the G7 countries - excluding the US. Backus, Kehoe and Kydland (1994b) report output correlations with respect to the US that are in the range of 0.41 to 0.76.

[14] The exclusion might be justified given that German re-unification is considered an outstanding event. Singularities of this type qualify for dominating the statistical properties of a time series given a relatively small sample size. Thus the German experience may rather distort than elucidate the picture of fundamental economic relationships that the researcher attempts to gain.

wages, it is attempted to preserve as much commonalities as possible to give a comparison some meaning. A basic assumption in both models is that preferences are identical within and across countries allowing to discuss the decisions of a representative consumer. Each country specifies in the production of an intermediate (composite) good using capital and labor. Final goods are produced using domestic and foreign intermediate goods that are aggregated by a CES production function. Final goods can be converted into consumption and investment without any costs. In both models, labor is considered to be immobile internationally. Throughout this section, we adopt the convention to use capital letters unless there are differences between individual consumers or producers that require a distinct notation. Following chronology, this section starts out by developing a streamline version of the open-economy model by Backus, Kehoe and Kydland (1994a, 1995).

3.1 The Trade Channel in a Flexible-Price Open-Economy Model

Each country $i = 1, 2$ is represented by a single consumer that stands for a large number of like agents. The consumers' preferences are described by an expected lifetime utility function of the form

$$U_i = E_0 \left[\sum_{t=0}^{\infty} \beta^t u \left(C_{it}, 1 - N_{it} \right) \right] \tag{1}$$

where C_i and N_i denote consumption and employment in country i. For this model, it is assumed that preferences are adequately described by the period utility function $u \left(C_{it}, 1 - N_{it} \right) = \frac{1}{\gamma} \left[C_{it}^{\mu} \left(1 - N_{it} \right)^{(1-\mu)} \right]^{\gamma}$. Each country specializes in the production of an intermediate good that is denoted by A for country 1 and B for country 2. Agents in both countries have access to a Cobb-Douglas production function using capital K_i and labor N_i. The shares of good A that are consumed by agents in country 1 and 2 are labelled as A_1 and A_2. A similar notation is adopted for good B[15]. Thus, A_2 is the export from country 1 to country 2 whilst B_1 is the import of country 1 from country 2. This gives rise to the resource constraints of intermediate goods

$$\begin{aligned} A_{1t} + A_{2t} &= Z_{1t} K_{1t}^{\theta} N_{1t}^{(1-\theta)} \\ B_{1t} + B_{2t} &= Z_{2t} K_{2t}^{\theta} N_{2t}^{(1-\theta)}. \end{aligned} \tag{2}$$

[15] From the perspective of country 1, A_1 can be interpreted as the domestically-produced good used in the final production whilst B_1 represents the set of importable goods in final production. A similar interpretation applies to country 2 where B_2 and A_2 denote the domestic and importable goods respectively.

Here, Z_i indicates the technological progress in country i; θ is a production parameter that defines the capital income share in intermediate output. Domestic and foreign intermediate goods are aggregated to final goods Q_i using a CES function. At the final stage of production, there is no need of capital and labor input. Final goods Q_i are converted into consumption C_i and investment X_i purchases. The resource constraints at the final goods stage can now be formulated as:

$$\begin{aligned} Q_{1t} &= \left((1-w)^{1/\rho} A_{1t}^{(\rho-1)/\rho} + w^{1/\rho} B_{1t}^{(\rho-1)/\rho}\right)^{\left(\frac{\rho}{\rho-1}\right)} = X_{1t} + C_{1t} \\ Q_{2t} &= \left(w^{1/\rho} A_{2t}^{(\rho-1)/\rho} + (1-w)^{1/\rho} B_{2t}^{(\rho-1)/\rho}\right)^{\left(\frac{\rho}{\rho-1}\right)} = X_{2t} + C_{2t} \end{aligned} \tag{3}$$

w is a weighting parameter indicating preferences for domestic goods if $0 < w < \frac{1}{2}$[16]. For $w = \frac{1}{2}$, domestic and foreign goods are equally valued. The parameter ρ in the CES function defines the intratemporal elasticity of substitution between domestic and foreign intermediates with $\rho > 0$[17]. Let q_1 and q_2 be the prices of A_1 and B_1 respectively. The equilibrium prices can be computed from the marginal rate of transformation in the CES function, evaluated at equilibrium quantities:

$$\begin{aligned} q_{2t} &= \tfrac{\delta Q_{1t}(A_{1t}, B_{1t})}{\delta B_{1t}} \\ q_{1t} &= \tfrac{\delta Q_{1t}(A_{1t}, B_{1t})}{\delta A_{1t}}. \end{aligned}$$

Defining domestic output as the sum of consumption, investment and net exports in terms of domestic goods, one arrives at

$$Y_{1t} = (C_{1t} + X_{1t})/q_{1t} + \left(A_{2t} - \frac{q_{2t}}{q_{1t}} B_{1t}\right). \tag{4}$$

The ratio of the import price over the export price defines the terms of trade P_t^{tot} by:

$$P_t^{tot} = \frac{q_{2t}}{q_{1t}} = \left(\frac{w}{1-w}\right)^{1/\rho} \left(\frac{A_{1t}}{B_{1t}}\right)^{1/\rho}. \tag{5}$$

Given the measure of relative prices, we are able to express country 1's external balance as ratio to output as

$$NEX_{1t} = \left(A_{2t} - P_t^{tot} B_{1t}\right)/Y_{1t}. \tag{6}$$

The corresponding foreign variables are defined analogously. The stocks of capital are assumed to evolve according to

$$K_{it+1} = (1-d) K_{it} + X_{it} - \Phi(K_{it+1}, K_{it}) \tag{7}$$

[16] This parameter reflects the empirical fact that domestic goods generally account for more than a proportionate share in domestic output. Amongst trade theorist, this finding came to be known as home bias puzzle.

[17] Formally, the intratemporal elasticity of substitution is defined as: $\rho = -\frac{\delta \log(a_1/b_1)}{\delta \log(q_1/q_2)}$.

where d is the depreciation rate of physical capital. The term $\Phi(K_{it+1}, K_{it})$ captures the costs of adjusting the capital stock. Following Kollmann (1999), $\Phi()$ takes the functional form of $\frac{1}{2}\phi\left(K_{it+1} - K_{it}\right)^2 / K_{it}$ so that the costs increase with the magnitude of the adjustment. For $\phi = 0$, changes in the capital stock do not incur any costs. Finally, the dynamics of this model come in by shocks to domestic and foreign technology. By assumption, technology follows an AR(1) process and is subject to independent and identically distributed shocks. This gives rise to the representation

$$Z_t = \Gamma Z_{t-1} + \varepsilon_t \tag{8}$$

with $z = [z_{1,} z_2]$ and $\varepsilon = [\varepsilon_1, \varepsilon_2]$.

Let s denote the vector of state variables with $s = [K_1, K_2, Z_1, Z_2]$. The competitive equilibrium consists of a set of decision rules for $C_1(s), C_2(s), X_1(s), X_2(s), N_1(s), N_2(s)$, $A_1(s), A_2(s), B_1(s)$ and $B_2(s)$ such that i) agents in country 1 and 2 maximize lifetime utility (1), ii) intermediate firms rent capital and labor until marginal costs equal marginal revenue, iii) the resource constraints (2)-(3) are binding and iv) the transversality condition $\lim_{s\to\infty} \beta^s K_{it+s} = 0$ is met. Henceforth, we refer to this model as the "flexprice" model as opposed to the "rigidprice" model outlined in the following subsection.

3.2 The Trade Channel in a Sticky-Price Model with Monopolistic Competition

The integration of monopolistic competition and rigid prices comes at the cost of a higher complexity. Because the technical aspects of these models have been extensively discussed in Obstfeld and Rogoff (1996), Betts and Devereux (2000) and Kollmann (1999), we only present the basic structure of the model.

The model consists of two countries and we invoke again the help of two agents that represent the decisions made by consumers and producers in each country. As in the flexprice model, the representative agent of country $i = 1, 2$ is assumed to maximize lifetime utility

$$U_i = E_0 \left[\sum_{t=0}^{\infty} \beta^t u\left(C_{it}, \frac{M_{it}}{P_{it}}, 1 - N_{it}\right) \right] \tag{9}$$

where C_i and N_i denote aggregate consumption and labor in country i. The term M_i/P_i reflects the amount of real balances willingly held by the representative agent; M_i defines the amount of nominal balances and P_i stands for the aggregate consumption-based price index in country i. For concreteness, instantaneous utility takes the functional form

$u\left(C_{it},\frac{M_{it}}{P_{it}},1-N_{it}\right)=\frac{1}{\gamma}\left[\left(C_{it}^{\eta}+\kappa\left(\frac{M_{it}}{P_{it}}\right)^{\alpha}\right)^{\frac{1}{\eta}}\right]^{\frac{1}{\gamma}}-N_{it}$. Like in the flexprice model, the economies are characterized by a two-stage production process. By assumption, the representative agent controls all firms in his country - at the final and intermediate production stage. This assumption is akin to saying that all shares within a country are held by domestic agents.

The final good sector is assumed to be perfectly competitive. A CES aggregation technology is used and baskets of domestic and foreign intermediate goods serve as input factors. Formally, final goods in country 1 and 2, denoted by Q_1 and Q_2, are produced by

$$\begin{aligned} Q_{1t} &= \left((1-w)^{1/\rho}A_{1t}^{(\rho-1)/\rho}+w^{\frac{1}{\rho}}B_{1t}^{(\rho-1)/\rho}\right)^{\rho/(\rho-1)} &= X_{1t}+C_{1t} \\ Q_{2t} &= \left(w^{\frac{1}{\rho}}A_{2t}^{(\rho-1)/\rho}+(1-w)^{1/\rho}B_{2t}^{(\rho-1)/\rho}\right)^{\rho/(\rho-1)} &= X_{2t}+C_{2t} \end{aligned} \tag{10}$$

with $\rho>0$ denoting the intratemporal elasticity of substitution between domestic and foreign goods. As in the flexprice model, $w\,\epsilon\,(0,1)$ indicates a preference for domestic goods if $0<w<\frac{1}{2}$. A_1 and B_1 are the basket of domestic and foreign goods demanded in the final goods production of country 1. Likewise, B_2 and A_2 are composites of domestic and foreign goods used in the production of the final good in country 2. These baskets are defined by

$$\begin{aligned} A_{1t} &= \left(\int_0^1 a_{1t}\left(u\right)^{(\upsilon-1)/\upsilon}\right)^{\upsilon/(\upsilon-1)} & B_{1t} &= \left(\int_0^1 b_{1t}\left(u\right)^{(\upsilon-1)/\upsilon}\right)^{\upsilon/(\upsilon-1)} \\ A_{2t} &= \left(\int_0^1 a_{2t}\left(u\right)^{(\upsilon-1)/\upsilon}\right)^{\upsilon/(\upsilon-1)} & B_{2t} &= \left(\int_0^1 b_{2t}\left(u\right)^{(\upsilon-1)/\upsilon}\right)^{\upsilon/(\upsilon-1)} \end{aligned}$$

where $\upsilon>1$ defines the intratemporal elasticity of substitution between intermediate goods produced in the same country. By assumption, there is a large number of intermediate firms in each country producing differentiated goods. The intermediate firm u in country 1 produces the good $a\left(u\right)$. For convenience, u is defined on the interval $\left[0,1\right]$. The intermediate good $a\left(u\right)$ may be used in the final goods production of country 1, $a_1\left(u\right)$, and country 2, $a_2\left(u\right)$. The price charged by the intermediate firm u in country i is denoted by $p_i^a\left(u\right)$. The notation for intermediate goods produced in county 2 is likewise. $b_1\left(u\right)$ and $b_2\left(u\right)$ are intermediate goods of type u that are used in the final goods production of country 1 and 2 respectively. Analogously, the price for this good is $p_1^b\left(u\right)$ in country 1 and $p_2^b\left(u\right)$ in country 2. We adopted the convention that prices are always quoted in the buyers currency.

By assumption, final goods producers minimize costs when producing some amount of the final good Q. Let P_i^a and P_i^b denoted the consumption-based price indices for intermediate goods A and B in country i that minimize a final goods producer's costs.

Intuitively, P_i^a reflects the minimal expenditure that is necessary to buy one unit of the composite good A in country i. Then, it can be shown that the price indices take the functional forms

$$\begin{aligned} P_{1t}^a &= \left(\int_0^1 a_{1t}(u)^{(1-\upsilon)}\right)^{1/(1-\upsilon)} & P_{1t}^b &= \left(\int_0^1 b_{1t}(u)^{(1-\upsilon)}\right)^{1/(1-\upsilon)} \\ P_{2t}^a &= \left(\int_0^1 a_{2t}(u)^{(1-\upsilon)}\right)^{1/(1-\upsilon)} & P_{2t}^b &= \left(\int_0^1 b_{2t}(u)^{(1-\upsilon)}\right)^{1/(1-\upsilon)}. \end{aligned} \tag{11}$$

P_i^a and P_i^b may be thought of as disaggregated price indices of an economy i where only two types of goods exist. The disaggregated price indices give rise to construct an aggregate price index for an economy. By the same logic, one may ask what is the minimal expenditure necessary to buy one unit of the final good Q? Under the premise that final goods producer's costs are minimized, the aggregate consumption-based price indices for country 1 and 2, P_1 and P_2, are defined by

$$\begin{aligned} P_{1t} &= \left[(1-w)\left(P_{1t}^a\right)^{(1-\rho)} + w\left(P_{1t}^b\right)^{(1-\rho)}\right]^{1/(1-\rho)} \\ P_{2t} &= \left[w\left(P_{2t}^a\right)^{(1-\rho)} + (1-w)\left(P_{2t}^b\right)^{(1-\rho)}\right]^{1/(1-\rho)}. \end{aligned} \tag{12}$$

Implicit to the computation of aggregated and disaggregated price indices is the derivation of optimal demand functions. Say, a final goods producer intends to achieve some output level Q. By minimizing costs, this producer compares the prices of the composite goods A and B and then chooses optimal quantities according to

$$\begin{aligned} A_{1t} &= (1-w)\left[\frac{P_{1t}^a}{P_{1t}}\right]^{-\rho} Q_{1t} & B_{1t} &= w\left[\frac{P_{1t}^b}{P_{1t}}\right]^{-\rho} Q_{1t} \\ A_{2t} &= w\left[\frac{P_{2t}^a}{P_{2t}}\right]^{-\rho} Q_{2t} & B_{2t} &= (1-w)\left[\frac{P_{2t}^b}{P_{2t}}\right]^{-\rho} Q_{2t}. \end{aligned} \tag{13}$$

Having chosen the amount of factor inputs A and B, the final goods producer may now choose amongst individual goods of type $a(u)$ and $b(u)$. Similarly to equations (13), optimal demand functions for individual goods $a(u)$ and $b(u)$ are given by

$$\begin{aligned} a_{1t}(u) &= \left[\frac{p_{1t}^a(u)}{P_{1t}^a}\right]^{-\upsilon} A_{1t} & b_{1t}(u) &= \left[\frac{p_{1t}^b(u)}{P_{1t}^b}\right]^{-\upsilon} B_{1t} \\ a_{2t}(u) &= \left[\frac{p_{2t}^a(u)}{P_{2t}^a}\right]^{-\upsilon} A_{2t} & b_{2t}(u) &= \left[\frac{p_{2t}^b(u)}{P_{2t}^b}\right]^{-\upsilon} B_{2t}. \end{aligned} \tag{14}$$

To provide an additional perspective on the aggregate variables, let nominal GDP of country 1 be defined as the sum of the composite good a that is used at home and abroad in terms of domestic currency units. Applying this definition analogously to country 2, one arrives at

$$\begin{aligned} Y_{1t} &= P_{1t}^a\left(A_{1t} + A_{2t}\right) \\ Y_{2t} &= P_{2t}^b\left(B_{1t} + B_{2t}\right). \end{aligned} \tag{15}$$

Examining a country's external balance, one may realize that A_2 is the total quantity of exports from and B_1 is the total quantity of imports to country 1. Conversely, noting that P_1^a and P_1^b may be interpreted as export and import price deflators, country 1's terms of trade P^{tot} are simply the ratio of the import price deflator over the export price deflator: $P^{tot} = P_1^b / P_1^a$. Then, it is straightforward to express country 1's nominal net export balance as ratio to domestic GDP by

$$NEX_{1t} = \left(P_{1t}^a A_{2t} - P_{1t}^b B_{1t}\right) / Y_{1t}. \tag{16}$$

Another aspect concerns the relationship of prices. Because no impediments to trade in intermediate goods are assumed, arbitrage assures equality of prices across countries. If e is for the nominal exchange rate between both countries, the law of one price (LOP) then implies:

$$p_{1t}^a (u) = e_t \times p_{2t}^a (u)$$
$$p_{1t}^b (u) = e_t \times p_{2t}^b (u) .$$

A direct implication of LOP is purchasing power parity (PPP) which states that aggregate price levels are equal across countries once converted into a common currency. Hence, we have $P_{1t}^a = e_t \times P_{2t}^a$ and $P_{1t}^b = e_t \times P_{2t}^b$.

3.2.1 Intermediate Goods Production

In both countries, the intermediate goods sectors are characterized by monopolistic competition and staggered price and wage setting. There operate a large number of firms each producing a differentiated good u with $u \in [0, 1]$. Since the decision problems are identical across intermediate firms and across countries - although their goods are not - we focus on the calculus of the producer u in country 1[18]. This producer has access to a Cobb-Douglas production function

$$y_{1t} (u) = z_{1t} k_{1t}^{\theta} (u) n_{1t}^{1-\theta} (u)$$

where $k(u)$ denotes the stock of physical capital that is demanded by the firm u at the nominal rental cost R_1. $n_1 (u)$ is a composite labor index that aggregates different kinds of labor h required by firm u. z_1 is a technology parameter that is common to all intermediate producers in country 1. An intermediate producers' revenue is simply the

[18] The considerations for country 2 are totally identical. It is simply so burdensome in terms of notational effort, that, we think, the advantage of a more stringent exposition outweights the lack of "completeness".

price that it charges domestic and foreign consumers to pay time the amount of goods being sold. On the other hand, the use of capital and labor generate costs. Say that $\digamma'$ summarizes the costs renting capital and labor necessary to produce one unit of output. Given the optimal demand (14) and the revenue and cost functions, the intermediate firm's profit function $\pi_1(u)$ is then defined by[19]

$$\pi_{1t}(u)(p_{1t}^{a}(u)) = (p_{1t}^{a}(u) - \digamma'(R_{1t}, w_{1t}(u))) \times (a_{1t} + a_{2t}) \times \left(\frac{p_{1t}^{a}(u)}{P_{1t}^{a}}\right)^{-\upsilon}. \tag{17}$$

3.2.2 Aggregate Budget Constraint

Let us start out by looking at the funding site of the budget constraint. Recalling that the representative agent in country 1 has control over all intermediate firms, it also receives their profits. Accumulating the profits of all intermediate firms, the agent in country 1 receives the aggregate profits $\Pi_1 = \int \pi_1(u)\,\delta u$. Further, the agent receives labor income from all intermediate firms. Total labor income G is a function of the nominal wage rate $w(h)$ for type h labor and the amount of type h labor $n(h)$ employed in equilibrium: $G_1(w_1(h), n_1(h))$. The agent may still hold some amount of nominal balances M_1 and receives a nominal transfer T_1. The two countries may exchange resources by trading a riskless nominal bond D denominated in country 1's currency. Say, that D pays a nominal return of $(1+i)$. The resources may be spent to finance private consumption C_1, investments into the capital stock X_1, the acquisition of new bonds D and nominal balances M_1. These considerations are summarized by the period budget constraint

$$M_{1t+1} + D_{t+1} + P_{1t}C_{1t} + P_{1t}X_{1t} = M_{1t} + D_t(1+i_t) + T_{1t} + \Pi_{1t} + G_{1t}. \tag{18}$$

where the nominal transfer $T_{1t} = M_{1t+1} - M_{1t}$. The stock of capital evolves-like in the flexprice model-according to

$$K_{1t+1} = (1-d)K_{1t} + X_{1t} - \Phi(K_{1t+1}, K_{1t}) \tag{19}$$

where d is the depreciation rate of physical capital. The term $\Phi(K_{1t+1}, K_{1t})$ captures the costs of adjusting the capital stock and takes the functional form $\frac{1}{2}\phi(K_{1t+1} - K_{1t})^2 / K_{1t}$. The evolution of the capital stock and the period budget constraint are defined analogously for country 2.

[19] Realistically, an intermediate producer uses different types of labor h. So, he also pays different types of wages $w(h)$. $w_1(u)$ may be thought of as wage index that firm u has to pay. Formally, $w_1(u) = \int n(h,u)\, w_1(h,u)\,\delta h$.

3.2.3 Price and Wage Setting

Due to monopoly power, the intermediate producer u maximizes its profits $\pi_1(u)$ by setting its price $p_1^a(u)$ appropriately. One may conceive the representative agent as supervisory board of any intermediate firm that tells each firm how to set its price. If any intermediate producer were allowed to change the price at any time, individual and aggregate prices are expected to fully adjust to shocks with a merely one period lag. Presumably, the model's predictions are quite similar to the flexprice model[20]. Prolonging the adjustment periods, staggered price and wage setting is introduced. Following Calvo (1983), it is assumed that only a fraction $(1-\delta_p)$ with $0 < \delta < 1$ of intermediate producers is allowed to reset its price. Imposing this price-setting regime, the law of motion for P_1^a is given by

$$\left(P_{1t}^a\right)^{1-\upsilon} = \delta_p \left(P_{1t-1}^a\right)^{1-\upsilon} + (1-\delta_p)\left(p_{1t}^a(u)\right)^{1-\upsilon}. \tag{20}$$

Yet, it has not been said something about the determination of wages. As it turns out that this is of minor importance for the transmission of business cycles across countries, we only give a brief sketch[21]. Each consumer h , $h \epsilon [0,1]$ has monopolistic power over the supply of type h labor $n_1(h)$. Labor demand is a function of intermediate producers' output and the rental costs of type h labor $w_1(h)$. Facing the labor demand functions, consumer h maximizes lifetime utility by choosing the nominal wage rate $w(h)$. Assuming that nominal contracts are valid for some period of time, only a fraction δ_w with $0 < \delta_w < 1$ of consumers is allowed to change the wage rate it charges producers to pay. Defining the aggregate wage index in country 1 by $W_{1t} = \left(\int w_{1t}(h)^{1-\psi}\,\delta h\right)^{1/(1-\psi)}$, rigidities in nominal wage contracting implies the following law of motion for the aggregate wage index in country 1

$$\left(W_{1t}\right)^{1-\psi} = \delta_w \left(W_{1t-1}\right)^{1-\psi} + (1-\delta_w)\left(w_{1t}(h)\right)^{1-\psi}. \tag{21}$$

Needless to say that the assumptions on the price and wage determination hold analogously for country 2.

3.2.4 Equilibrium

Both countries are subject to shocks that affect either the state of technology z_i or the supply of nominal balances M_i^s. Let Z be a vector with $Z = [Z_1, Z_2, M_1^s, M_2^s]$. Like in

[20] Kollmann (1999) shows that under instantaneous price adjustments, the model's predictions are roughly identical to a flexible-price open-economy model.

[21] For a more extensive treatment, the reader is referred to Kollmann (1999).

the flexprice model, technology and money supply are assumed to follow AR(1) processes with

$$Z_{t+1} = \Gamma Z_t + \varepsilon_t \tag{22}$$

with $\varepsilon = [\varepsilon_{z1}, \varepsilon_{z2}, \varepsilon_{m1}, \varepsilon_{m2}]$. Let s denote the vector of state variables with $s = \left[K_1, K_2, D, e, M_1, M_2, P_1^a, P_2^b, W_1, W_2, Z_1, Z_2, M_1^s, M_2^s\right]$. The equilibrium consists of a set of decision rules for $M_1(s), M_2(s), X_1(s), X_2(s), p_1^a(u), p_1^b(u), p_2^a(u), p_2^b(u), w_1(h)$, $w_2(h)$ such that i) the representative agents in country 1 and 2 maximize lifetime utility (9), ii) intermediate firms maximize profits (17) iii) the resource constraints (10) and (18) are binding, iv) the supply equals the demand of physical capital $K_i = \int k_i(u)\,\delta u$, v) the supply equals the demand of labor $N_i = \int n_i(u)\,\delta u$, vi) the supply equals demand of nominal balances $M_i = M_i^s$, vii) world wide saving is zero $D_1 + D_2 = 0$ and viii) the transversality conditions $\lim_{s\to\infty} \beta^s K_{it+s} = 0$ and $\lim_{s\to\infty} \beta^s D_{it+s} = 0$ are met.

3.3 Numerical Results

There is no analytical solution neither to the "flexprice" nor "rigidprice" model. An approximate solution is obtained by linearizing the equilibrium conditions around the steady state. The resulting systems of difference equations are then solved by applying the Blanchard-Kahn (1982) algorithm[22]. The simulation and impulse response function analysis requires to assign numerical values to parameters. Table A.I in appendix A summarizes the benchmark parameter values around which the numerical analysis is conducted.

The basic dynamics underlying theoretical economies like the flexprice and rigidprice models have been extensively discussed in the literature (see Backus, Kehoe and Kydland (1994a and b), Baxter (1995) and Kollmann (1999)). Merely repeating this discussion here does not seem to be worthwhile. Instead, we deliberately discuss some of the dynamic properties in the context of the import share and the intratemporal elasticity of substitution. However, since the present models and parameterization diverge in some dimension from earlier versions, table V summarizes a number of properties that are thought to provide a rough characterization.

The variances have been normalized so that the standard deviations in output match

[22] The solution of a set of difference equations, the impulse response function analysis and the simulation studies have been performed using Matlab. The methodology has become a standard tool in macroeconomic theory so that we dismissed a detailed discussion here. An outline of the solution method and programs are available upon request.

an average value of 1.67. Both economies perform well in explaining the relative volatilities of output, consumption, investment and net exports. The volatility in the terms of trade is heavily underestimated by the flexprice model. In this dimension, the rigidprice model achieves a better fit of the data. Further, the large and positive contemporaneous correlation of consumption and investment with output are consistent with empirical estimates[23].

Simulation Results for Benchmark Parameterization

	Output	Consumption	Investment	Net Exports	Terms of Trade
	Standard Deviations in Percent				
Flexprice	1.67	0.61	5.23	0.28	0.44
Rigidprice	1.67	1.42	7.03	0.26	1.39
	Intra-National Correlations with Output				
Flexprice	1.00	0.94	0.96	-0.59	0.40
Rigidprice	1.00	0.56	0.97	-0.14	0.34
	Other Correlations				
	$corr\,(Y_1, Y_1)$	$corr\,(C_1, C_2)$		$corr\,(ToT_1, NEX_1)$	
Flexprice	0.25	0.60		-0.30	
Rigidprice	0.57	0.64		0.48	

Table V) Statistical Properties of the "Flexprice" and "Rigidprice" Model

i) Statistics are based on HP-filtered data; Moments are averages over 100 draws

Output and net exports are predicted to be negatively correlated in both economies. Given the dispersion of empirical estimates of the output - net export correlation as summarized in table I and IV, both models seem to be equally consistent with the data. As far as the relation between the terms of trade and net exports is concerned, the theoretical predictions differ fundamentally. The flexprice model implies an inverse relation (-0.30) between the external balance and the terms of trade. In contrast, the rigidprice model involves almost a co-movement in relative prices and net exports, predicting a correlation of 0.48. In this dimension, the benchmark flexprice model appears to be more consistent with the data. However, it will be demonstrated in section 5 that the rigidprice model's anomaly is directly linked to the intratemporal elasticity of substitution. For small variations in this parameter, this model correctly predicts an inverse relationship between

[23] Cooley and Hansen (1995) and Baxter (1995) report estimates for correlations of consumption and investment with output that are in the range of 0.8 and 0.9 respectively.

relative prices and net exports. Both economies generate a co-movement in output and the terms of trade. The predicted correlation coefficients (0.40 and 0.34 respectively) suggest a procyclical behavior of relative price movements. These predictions are consistent with the experiences of Japan and the UK only. In any other G7 country, movements in output and relative prices are inversely related. Because the evidence is ambiguous, it remains to be seen how these models perform along this dimension.

Both models share at least one major drawback. Empirically output is much higher correlated across countries than consumption. For instance, we find an average output correlation of 0.20 amongst G7 countries whereas the average consumption correlation amounts merely to 0.06. This observation has been made originally by Backus, Kehoe and Kydland (1992) and came to be known as the output-consumption correlation puzzle. Sharing this feature with many models of international business cycle theory, the flexprice and the rigidprice model fail to replicate the order in the output-consumption correlation.[24]. The conclusions, however are somewhat scant. Arguably, the rigidprice model happens to close the gap between cross-country output and consumption correlations much better than the flexprice model. Also, the predicted output correlations are in the range of 0.6 as commonly reported by many researchers[25]. However, in terms of matching the average cross-country output correlations amongst G7 countries presented in table I, the flexprice model is much closer to the data.

The simulation results are conditional to the benchmark parameterization reported in appendix A. Modifications in parameter values are likely to affect them. Subsequently, the import share and the intratemporal elasticity of substitution are iterated over plausible intervals to see how theoretical predicts are affected. It is intended to analyze to what extent differences in these parameters influence the international transmission of economic fluctuations and potentially account for the variation in the stylized facts of the business cycle across the major industrialized countries.

4 Openness and Business Cycle Synchronization

If the trade channel is important for the transmission of business cycles, then the magnitude of the trade volume is expected to be a key factor. The ratios of imports and exports to output have become standard measures that characterize an economy's dependence

[24]For example, see the excellent survey by Baxter (1995).

[25]In a study with a group of 10 OECD countries, Backus, Kehoe and Kydland (1995) report cross-country output correlations with respect to the US that suggest an average correlation around 0.6.

upon foreign trade. These measures have also been interpreted as indicators of an economy's openness and we continue to denote them by w. Conceivably, w denotes the fraction of domestic output that is affected by foreign demand. It seems then straightforward to maintain that the influence of foreign demand on domestic output might increase with w[26]. This logic bears a testable implication. If the impact of foreign demand on domestic output is a positive function of w, then so is the cross-country output correlation. Before the empirical evidence is summarized, the theoretical predictions are examined.

4.1 Theoretical Predictions

Unless simplifying assumptions are imposed on preferences and technology - like in Dellas and Canova (1993) - there is no explicit solution to the flexprice and rigidprice model. Given the model's current structures, we are unable to derive analytical formulas that relate the cross-country output correlation to the import share. Instead, we will rely on the evidence of a numerical experiment. The two benchmark economies are simulated repeatedly for different values of w. In particular, we consider import shares in the range from 4 to 32 percent. The evidence is summarized in figure 4.1. Although variations in w affect many variables, our focus is on the cross-country output correlation and the correlation between important trade variables: the terms of trade and net exports and output and net exports.

The economies differ in their predictions how the import share affects the co-movements in national outputs, the terms of trade and net exports. The cross–country output correlation appears to increase with the import share in the rigidprice model. There is no evidence of a theoretical relationship in the flexprice model. The latter finding confirms earlier observations in Ravn (1997). As noted before, country 1's terms of trade and net exports are positively correlated in the rigidprice model and negatively correlated in the flexprice model. The correlation slightly increases with the import share in the rigidprice model and falls in the flexprice model. Output and net exports are negatively correlated in the flexprice model. This relationship appears to be stable and independent of w. For small values of the import share, output and net exports display an inverse relationship in the rigidprice model. As w grows, the correlation increases and eventually becomes positive. Note that only the contemporaneous correlation function between output and net exports reverses the sign for small variations in w. In order to understand these results, it may be instructive to look at various impulse response functions. We begin by

[26] The argument relies on the implicit assumption that foreign demand is a normal "good".

discussing the behavior of the flexprice model. Since the arguments apply symmetrically to country 2, we only discuss the responses to a technology shock in country 1. The upper panels of figure 4.2 display the responses of the terms of trade and net exports of country 1. Changes in demand for intermediate goods in both countries are shown in the lower panels. We stick to the notation as used in the theoretical model. To demonstrate how different values of w affect the model's predictions, the impulse response functions are computed for a moderate import share of 5 percent (left panels) and for a rather extreme import share of 30 percent (right panels). Country-specific shocks may be transmitted abroad by interdependencies in trade and by some autocorrelation structure in the processes of technology that is reflected by non-zero off-diagonal elements of Γ in equation (8).

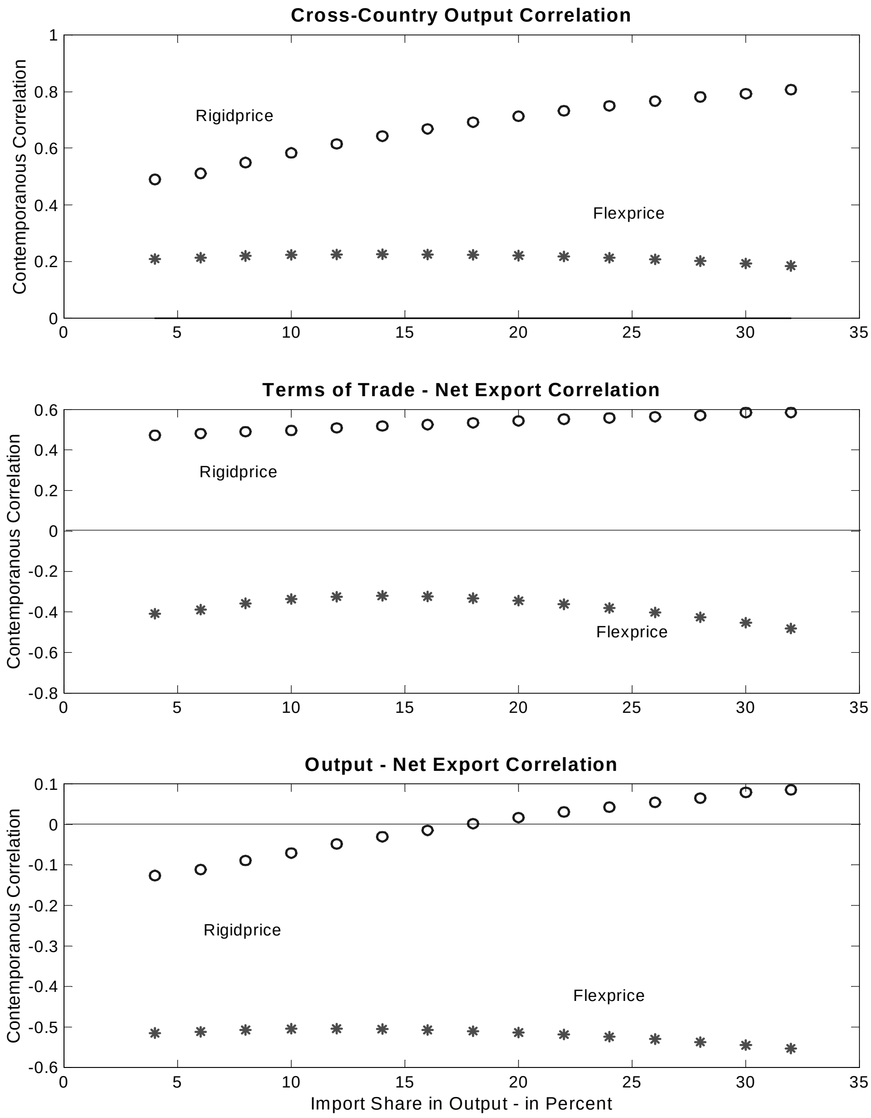

Figure 4.1: Import Share and Various Correlation Measures

Because the import share does not affect the autocorrelation structure, we rule out this mechanism by setting the off-diagonal elements to zero. This allows for a plain view on the transmission mechanism due to trade flows.

The shock to Z_1 raises the supply of goods of type A absolutely and relatively to goods of type B. The supply shock means a volume-based increase in wealth for residents in country 1. Further market clearing requires the price of good A to fall relative to the price of good B. Hence, the relative price, the terms of trade between country 1 and 2, increases as can be recognized in the upper panels. Relative price changes encompass wealth and substitution effects. Wealth effects from relative changes in the supply of goods can be distinguished from wealth effects due to alterations in the terms of trade[27].

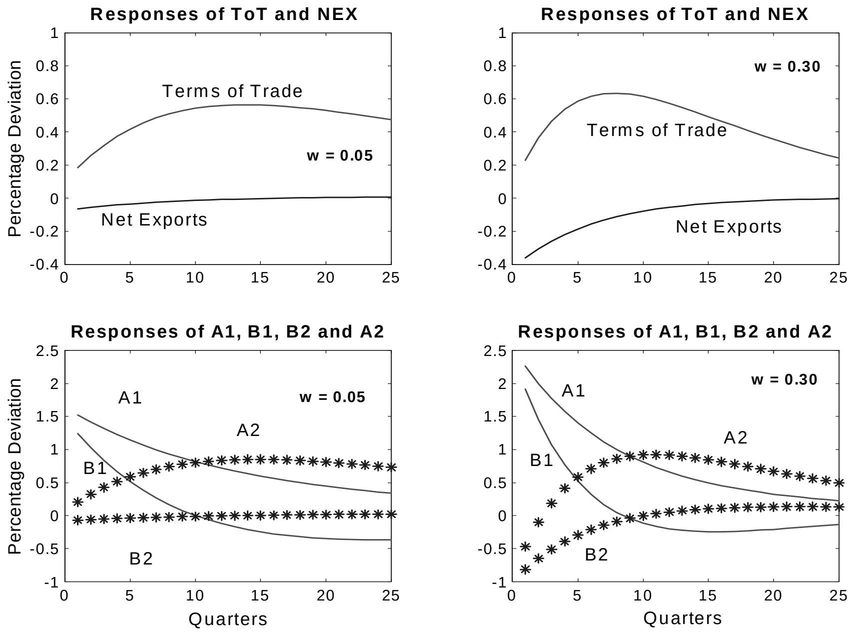

Figure 4.2: Impulse Response Functions of the Flexprice Model

Four effects from movements in relative prices can be isolated that are important in understanding the impulse response functions in figure 4.2.

i) The decline in prices of good A implies a positive wealth effect for residents in both countries.

ii) The positive wealth effects[28] stimulate demand for both intermediate goods. Given that total supply of good B is unchanged[29], the price of good B rises and implies a negative wealth effect for residents in both countries.

iii) The deterioration country 1's terms of trade lowers current income of residents in country 1 and raises current income of residents in country 2. Hence, the change in

[27] There will be two source from which wealth effects can arise. We distinguish between wealth effects from changes in quantities - increases or decrease in the total supply of goods - and wealth effects from changes in relative prices. Obstfeld and Rogoff (1996) further distinguish between income and wealth effects that result from relative price changes. We abstract from this characterization and refer merely to volume-based or price-based wealth effects.

[28] Recall, that country 1's wealth increases due to price and volume effects.

[29] Essentially, changes in the total supply of good B are very small. In fact, the deviation from the steady state supply is less than 0.05 percent. Compared to the 1.5 percent deviation in the total supply of good A, it is reasonable to say that intermediate goods production in country 2 is unchanged.

relative prices induces a negative wealth effect in country 1 and a positive wealth effect in country 2.

iv) The shortfall in prices of good A and the increase in prices of good B raises the price of imports relative to the price of domestically-produced goods for residents in country 1. Inversely, importable goods become less expensive than domestic goods in country 2. The relative price change induces substitution effects of reverse sign.

The interaction of various price-based and volume-based wealth and substitution effects constitutes the mechanism that makes the impulse response functions in figure 4.2 difficult to understand. To sum up the basics: Due to the substitution effect iv), demand switches to the less expensive good A in both countries. The impulse response functions for good A always exceed their counterpart for good B in the lower panels of figure 4.2. The volume-based wealth effects always dominate price-based wealth effects. This explains why country 1's demand for intermediate goods (A_1, B_1) increases regardless of the particular value assigned to w. The size of the import share affects the allocation of intermediate goods across countries. It does so by governing the relative strength of priced-based wealth effects summarized under ii) and iii). For small w, the positive wealth effect from iii) dominates the negative influence described under ii). As w grows, the negative impact from ii) increases and eventually dominates the positive stimulus from the beneficial terms of trade effect iii). The price of current versus future consumption increases. Consistently, residents in country 2 substitute towards future consumption that is mirrored in the fall of (A_2, B_2). Country 2's output is nearly unaffected by the size of the import share. The reason is that the positive and negative wealth effects from ii) and iii) are small in magnitude and tend to balance each other. This explains the absence of any meaningful relationship between a country's openness and the cross-country output correlation in the flexprice model.

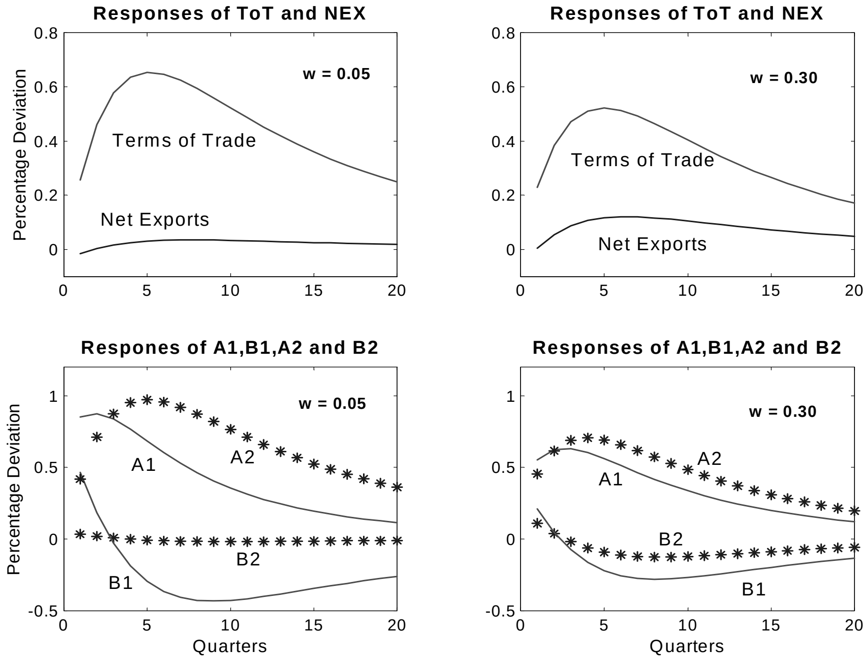

Figure 4.3: Impulse Response Functions of the Rigidprice Model

In contrast, the rigidprice model displays a positive relationship between the cross-country output correlation and the import share as can be verified in figure 4.1. When comparing figure 4.3 with figure 4.2, one recognizes similarities in the shape of the impulse response functions. Supposedly, the wealth and substitution effects leading to changes in prices and quantities are common to both - the flexprice and the rigidprice model. A positive technology shock in country 1 shifts the supply curve of monopolistic producers thereby triggering an increase in total supply of type A and a fall in the price of good A relative to good B. Country 1's terms of trade deteriorate as can be seen in the upper panels of figure 4.3. Relative price changes induce wealth and substitution effects that are similar to the flexprice model. Demand for good A is higher than for good B due to the substitution effect in both countries. Further, the rise in demand for intermediate goods is higher country 1 than in country 2 as country 1 benefits from the volume-based wealth effect. The main difference to the flexprice model lies in the extend to which country 2 suffers from the negative wealth effect summarized by ii). Recall that in the flexprice model, total supply of B has been nearly unchanged. Instead, country 1's increase in demand for good B solely raised the price of B, thus deferring country 2's demand. In the rigidprice setting, only a fraction $(1 - \delta_p)$ of monopolists in country 2 is allowed to increase the price when facing a higher demand schedule. Hence, the average price of good B - measured by the price index of B - rises by much less than in the flexprice model. Any monopolistic producer who has to stick to its preset price will optimally expand its production to meet the increase in demand for type B goods[30]. It is for this reason that idiosyncratic technological innovations produce co-movements in output across countries that are markedly higher than in a flexprice model. Furthermore, note that the import share w determines the fraction of total income spent on the imported good as can be seen in equations (13). Given some level of total output, demand for imported goods increases with the import share. As being argued above, it is the demand for imported goods that generates co-movements in output across countries. It is then straightforward to conclude that the stronger this demand channel, the higher the cross-country output correlation. Another way of looking at this relationship is to perceive w as that parameter governing the distribution of the volume-based wealth effect across countries. As w grows, wealth is being spread more equally across countries and the cross-country output correlation rises.

There is another difference between the flexprice and rigidprice model that has yet been mentioned. The flexprice model predicts that the deterioration in a country's terms of trade worsens with the openness. This can be verified by comparing the upper two panels in figure 4.2 . The rigidprice model's predictions stand in contrast to the flexprice model as can be seen in the upper panels of figure 4.3. The more final producers in country 2 value goods of type A, the stronger will be the export demand that producers in country 1 face and the smaller the decline in country 1's terms of trade. Hence, a stronger import demand by final goods producers in country 2 minimizes relative price changes. Both, the volume and the price effect induce correlations between output and net exports that increase with a country's openness in the rigidprice model. This correlation may even become positive for import shares beyond 20 percent as figure 4.1 suggests.

4.2 Empirical Evidence

The flexprice and rigidprice model give contradictory theoretical predictions how the magnitude of trade interdependence affects the contemporaneous correlations of output, net export and the terms of trade. We test the validity of these predictions[31] empirically in a cross-sectional dimension using quarterly data on gross domestic product and bilateral

[30] Of course, monopolistic producers will optimally expand their production only until marginal costs equal the price they charge for good B.

[31] Due to the lack of bilateral export and import price indices, we are unable to test empirically how the level of trade interdependence affects the terms of trade - net export correlation.

exports and imports from 1980:1 - 1999:4 as available from the IFS and DOTS tapes[32]. In particular, we consider two basic specifications that are encompassed within:

$$corr\,(y_i, y_k) = \alpha_0 + \alpha_1 w_{ik} + \varepsilon \tag{23}$$

and

$$corr\,(y_i, bnex_{ik}) = \alpha_0 + \alpha_1 w_{ik} + \varepsilon \tag{24}$$

$corr\,(y_i, y_k)$ denotes the correlation coefficient between the HP-filtered cyclical components of real GDP[33] between country i and k. Similarly, $corr\,(y_i, bnex_{ik})$ refers to the correlation coefficient between real GDP and bilateral net exports from country i to country k. w_{ik} stands for the average percentage share of imports from (exports to) country k in nominal GDP of country i[34]. e is the impact of other forces on the cross-country output correlation that are hopefully orthogonal to the level of trade interdependencies. We estimate equations (23) and (24) using alternatively the average shares of bilateral exports and imports in GDP over the period 1980-1999. The cross-country output and net exports - output correlations are computed as described in section 2. The key estimate in our equations is the parameter α_1. We test the null hypothesis $H_0 : \alpha_1 = 0$ against $H_1 : \alpha_1 \neq 0$. Table VI summarizes the test statistics.

Trade Interdependence and Unconditional Correlations

Specifications	α_1	t-statistic	White-statistic	R^2	DW
$corr\,(y_i, y_k) = \alpha_0 + \alpha_1 w_{ik}^{EX} + e$	0.135	3.403	2.506	0.225	1.93
$corr\,(y_i, y_k) = \alpha_0 + \alpha_1 w_{ik}^{IM} + e$	0.161	4.060	3.627	0.292	2.08
$corr\,(y_i, bnex_{ik}) = \alpha_0 + \alpha_1 w_{ik}^{EX} + e$	-0.001	-0.051	-0.058	0.0001	1.84
$corr\,(y_i, bnex_{ik}) = \alpha_0 + \alpha_1 w_{ik}^{IM} + e$	0.013	0.445	0.484	0.004	1.88

Table VI: Test statistics; w^{EX} and w^{IM} denote export and import shares respectively

Regression results are based on 42 sample observations

As far as the cross-country output correlation is concerned, we are able to reject the null hypothesis at conventional levels for both, the import and the export share. We

[32] See appendix B for a detailed description of the data.

[33] Nominal GDP has been denominated in US \$ using period average exchange rates. Then real GDP has been computed dividing nominal GDP by the US price deflator.

[34] Formally, let IM_t^{ik} be the imports of country i from country k and let denote y_t^i the gross domestic product of country i all at time t. Then the average bilateral import share over the sample period is defined by: $w_{ik} = \frac{1}{T}\sum_{t=1}^{T}\frac{IM_t^{ik}}{y_t^i}$. The average bilateral export shares are defined analogously.

find a positive and highly significant relationship between interdependencies in trade and cross-country output correlations within the group of G7 countries. Empirically, a one percent increase in the export share seems to raise the cross-country output correlation on average by 0.135. The impact of the import share is even stronger. The output correlation tends to increase by 0.161 if the import share goes up by one percentage point. There appears to be some evidence of heteroscedasticity in the residuals. Although the OLS estimator would be still unbiased under heteroscedastic errors, hypothesis testing can no longer be trusted. For that reason, equation (23) is re-estimated employing White's heteroscedasticity consistent variance-covariance estimator. The t-values are reported in the fourth column of table VI.

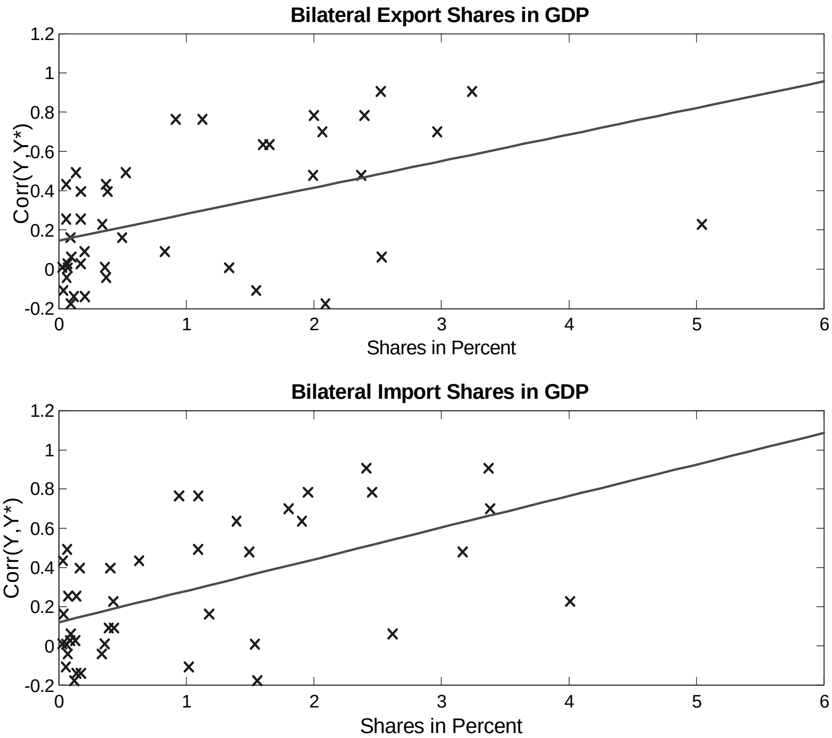

Figure 4.4: Trade Interdependence and Output Correlation amongst G7 Countries

Although the significance level marginally declines, the estimates of α_1 remain to be highly significant. Further, we tested the robustness of our findings using another measure of output. It turned out that the cross-country correlation of industrial production also increases with the level of bilateral trade. The corresponding coefficients are positive and highly significant[35].

[35] The point estimates are somewhat smaller with $\alpha_1 = 0.0673$ (2.68) for the export share in GDP. If the import share is used, the coefficient estimate is: $\alpha_1 = 0.0633\,(2.72)$. Figures in brackets report the t-values for White's heteroscedasticity consistent variance-covariance estimator.

Another perspective on these regression results is given in figure 4.4 that illustrates the trade - output association in the cross-sectional dimension. This figure attenuates somewhat the trade-output relationship suggested by the OLS estimates. The scatterplot reveals no systematic relationship between bilateral output-correlations and the level of trade. This evidence comes along with the fact that no statistical relationship is detected between the level of bilateral trade and the output-net export correlation. Neither the coefficient for the export share nor the import share are statistically significant. Positive and negative correlations between output and bilateral net exports can come along with high and low shares of bilateral trade leaving us unable to judge the theoretical predictions in this dimension.

As far as a country's openness is concerned, the evidence seems to support the rigidprice model. Idiosyncratic supply shocks can be transmitted abroad by trade thereby raising domestic and foreign output. The level of trade interdependence appears to be an import determinant how strong the trade channel turns out to be. If country-specific shocks to technology are believed to be an important empirical phenomena, then the level of bilateral trade is to account - at least partially - for the positive cross-country output correlation amongst the major industrialized countries.

5 Import Substitution and Business Cycle Synchronization

In the previous section, we attempted to explain how the magnitude of trade interdependence affects the transmission of country-specific shocks internationally. The focus shifts now to the more subtle question how the international transmission of shocks depends on the substitution possibilities of import goods. Addressing this question amounts to analyzing the degree to which domestic and importable goods are substitutable and how this affects contemporaneous relationships amongst macroeconomic variables.

5.1 Theoretical Predictions

As before, if one is to avoid unrealistically restrictive assumptions, there are no explicit solutions to either the flexprice nor the rigidprice model. Again, we rely on the results of a numerical exercise by simulating both models repeatedly and for different values of the intratemporal elasticity of substitution between domestic and foreign goods that has been denoted by ρ. Given the spectrum of empirical estimates of substitution elasticities - as summarized by Hooper and Marquez (1995) - it appears that the interval $[0,4]$ captures most likely the relevant values.

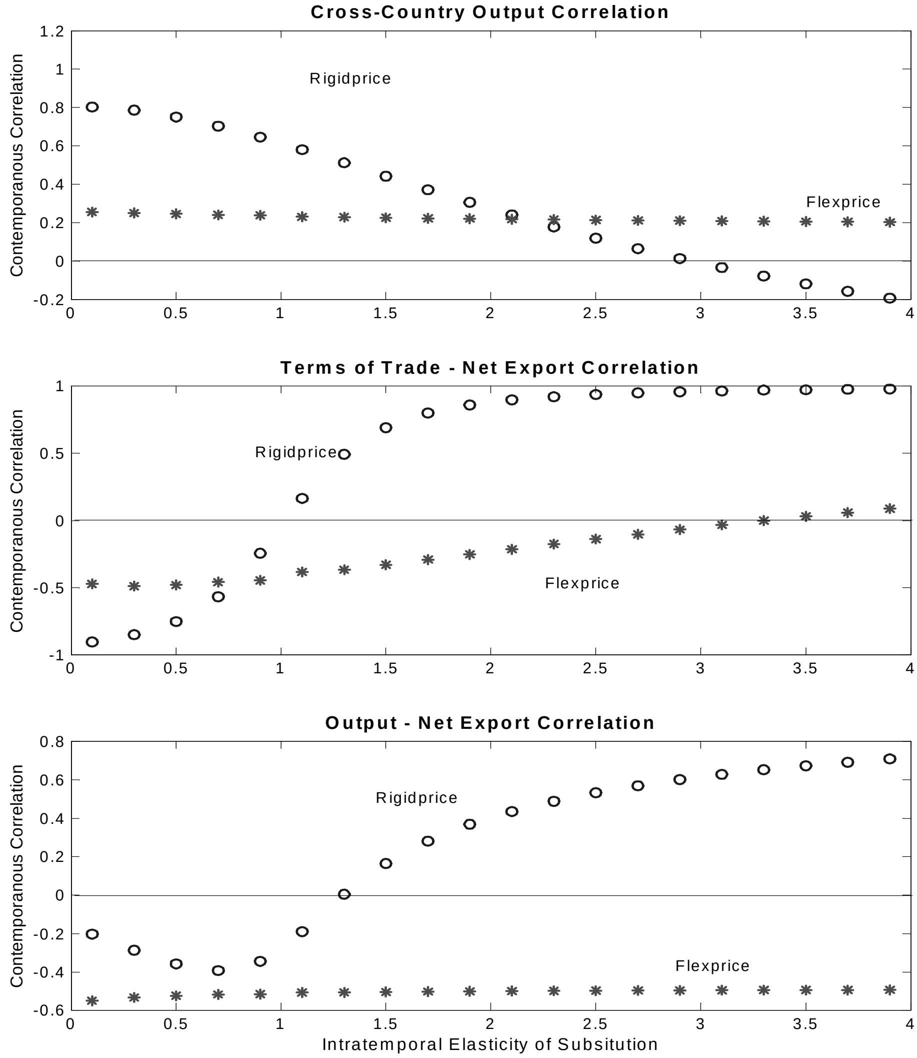

Figure 5.1: Intratemporal Elasticity of Substitution and Various Correlation Functions

Alterations in the calibration of ρ are supposed to affect many variables and relationships. Again, the focus is on three contemporaneous correlation coefficients that are likely to shed some light on the way how the transmission of economic fluctuations by trade flows is affected. In particular, the cross-country output correlation, the terms of trade - net export correlation and the output - net export correlation functions are examined. Figure 5.1 summarizes the results. Strikingly, the rigidprice model is more sensitive to changes in the elasticity of substitution than the flexprice model. The correlation coefficients reverse signs for small variation in ρ. A low intratemporal elasticity of substitution implies a positive cross-country output correlation and negative correlation coefficients between the terms of trade and net exports and output and net exports. As ρ increases, the cross-country output correlation falls and for ρ exceeding 3, output is negatively correlated across countries as shown in the upper panel of figure 5.1. The terms of trade - net export and output net export correlation rise as substitution possibilities increase. The correlation coefficients rise with ρ and become positive if ρ exceeds 1 and 1.4 respectively as can be verified in the lower panels of figure 5.1. The behavior of the flexprice model displays some similarities to the rigidprice model. The cross-country output correlation falls as ρ increases although there is no reversion in sign. The terms of trade - net export correlation rises as substitution of importable and domestic goods improves. There is also a reverse in sign as ρ exceeds 3.4. The output - net export correlation rises slightly as ρ increases. Generally, changes in the flexprice model are small compared to those in the rigidprice models. In order to understand these differences, it may be instructive to look at various impulse response functions.

Due to the symmetry argument, the discussion is largely confined to the response of country 1. The upper panels of figure 5.2 display the responses of the terms of trade and net exports of country 1. Changes in demand for intermediate goods in both countries are shown in the lower panels. We stick to the notation as used in the theoretical model. The impulse response functions are computed for rather extreme values of the intratemporal elasticity of substitution. The left panels in figure 5.2 display the responses for $\rho = 0.5$; the panels to the right show the responses for $\rho = 3.5$. Country-specific shocks may be transmitted abroad by interdependencies in trade and by some autocorrelation structure in the processes of technology that is reflected by non-zero off-diagonal elements of Γ in equation (8). Because the intratemporal elasticity of substitution does not affect the autocorrelation structure, we again rule out this mechanism by setting the off-diagonal elements to zero.

We begin by discussing the behavior of the flexprice model. The shock to productivity Z_1 induces volume-based wealth and substitution effects that emanate from the increase in total supply of good A and from improvements in the marginal products of capital and labor. Both stimulate the demand for consumption and investment in country 1. To match the rise in absorption, country 1's output in the final sector must increase, triggering a rise in 1's demand for intermediate goods A and B as can be recognized in the lower panels of figure 5.2. Because the shock to productivity raises the supply of goods A relative to goods B, the price of A must fall. Hence, country 1's terms of trade deteriorate whilst country 2's terms of trade improve. The inflow of intermediate goods from country 2 and the deterioration in country 1's terms of trade causes a temporary deficit in the trade balance.

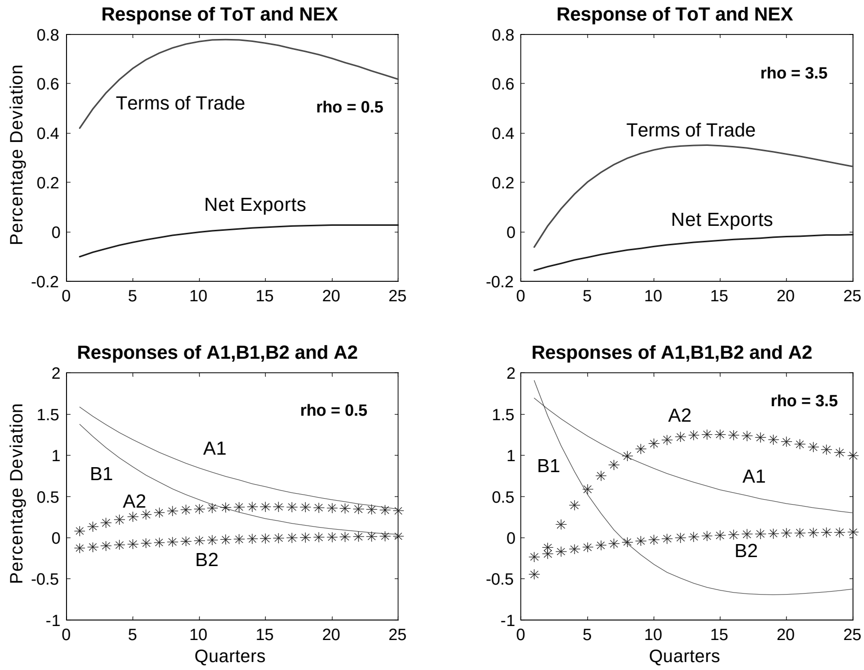

Figure 5.2: Impulse Response Functions of the Flexprice Model

These dynamics hold for a reasonable calibration of the intratemporal elasticity of substitution[36]. Importantly, the size of the intratemporal elasticity of substitution governs the degree to which the terms of trade change. If goods are rather poor substitutes ($\rho = 0.5$), sizeable relative price movements are needed to enforce goods market clearing. As ρ rises, relative price changes become smaller. This pattern can be observed in the upper panels of figure 5.2. As mentioned earlier, relative price changes are accompanied by wealth and substitution effects. The substitution effect is not used in the sense that goods of type B are replaced by goods of type A. The substitution effect involves a rise in demand for good A relative to good B. The degree to which demand for good A rises relative to good B is related to the change in relative prices. The larger the terms of trade effect, the smaller the substitution effect. As we have just seen, the importance of the terms of trade effects decreases as the intratemporal elasticity of substitution grows. For small values of ρ ($\rho = 0.5$), the terms of trade effect is substantial. From country 1's perspective, the increase in the price of importable goods and the decrease in the price of

[36]We consider values of the intratemporal elasticity of substitution as reasonable if they have some empirical support. As summarized by Hooper and Marquez, empirical estimates of ρ are in the range of $[0, 4]$.

exportable goods amounts to a negative wealth effects that partially offsets the positive volume-based wealth effect. Because the increase in total wealth is weakened, demand for A_1 and B_1 is lower for $\rho = 0.5$ compared to the case where ρ is set to 3.5. Additionally, the deficit in country 1's trade balance decreases as the rise in total wealth is weaker. All effects can be recognized in figure 5.2. From country 2's perspective, the terms of trade effect raises current wealth, thereby stimulating demand for A_2 and B_2. The stronger the terms of trade effect, the larger demand for intermediate goods in country 2. As can be recognized in figure 5.2, demand for A_2 and B_2 is higher for $\rho = 0.5$ than in the case where ρ is set to 3.5. This explain why output is higher correlated across countries when importable and domestic goods are rather complements than substitutes.

If importable and domestic goods are reasonable substitutes, changes in the relative supply of either good affect the price of both as they can be used interchangeably in the production process. The terms of trade depend negatively on the intratemporal elasticity of substitution. Conceivably, for some small value of ρ, an increase in the supply of A also reduces the price of B on impact. The terms of trade might even decrease on impact as can be verified in the upper right panel of figure 5.2. It is for this reason that the flexprice model predicts a positive contemporaneous correlation between the terms of trade and net exports for large values of ρ.

Consider then the responses of the rigidprice model in figure 5.3. Like in the flexprice model, the shock to productivity Z_1 induces wealth and substitution effects that arise from the increase in total supply of good A and from improvements in the production function. Both effects trigger an increase in demand for A_1 and B_1. The expansion in the supply of good A lets monopolistic producers in country 1 to lower their prices. In contrast, the import price of good B rises as monopolistic producer in country 2 face a higher demand schedule. From country 1's perspective, the terms of trade deteriorate as can be recognized in the upper panels of figure 5.3. As noted earlier, terms of trade changes encompass wealth and substitution effects. The increase in the terms of trade induces wealth effects that are positive for country 2 and a negative for country 1. Due to the substitution effect, intermediate producers replace good B by the cheaper good A. In the flexprice model, we observe price adjustments and the intratemporal elasticity of substitution determines the magnitude of relative price adjustments necessary to clear goods markets. In the rigidprice model, quantities adjust and the intratemporal elasticity of substitution governs the degree to which demand for intermediate goods reacts to relative price changes. That is, the intratemporal elasticity of substitution governs the extent to which the substitution effect dominates the wealth effects. For small values of

ρ ($\rho = 0.5$), the substitution effect is almost negligible and the wealth effects dominate.

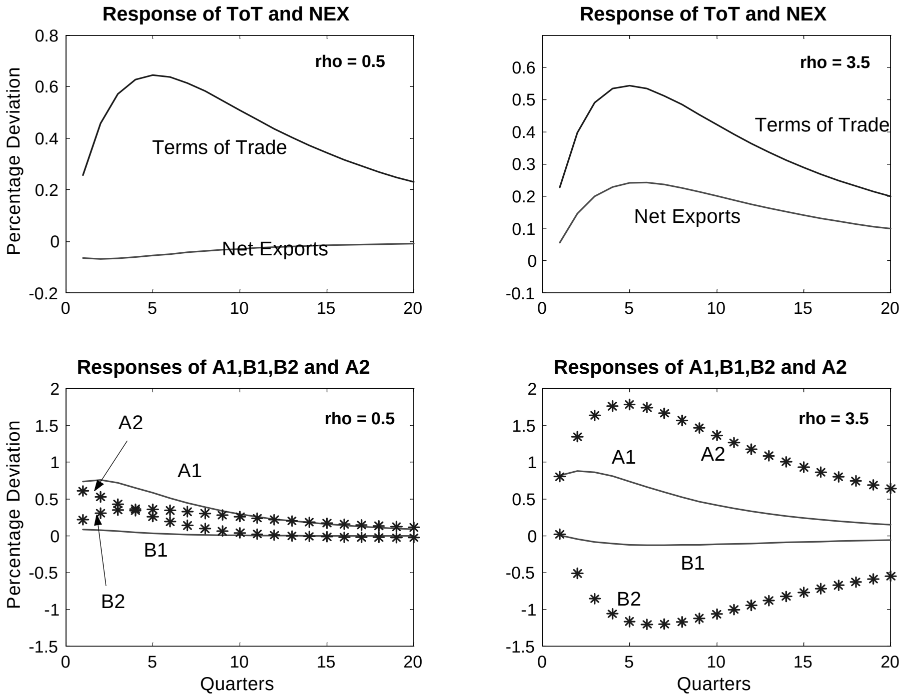

Figure 5.3: Impulse Response Functions of the Rigidprice Model

Country 1's demand for both intermediate goods increases while demand for good A_1 is only marginally higher than for good B_1. All effects can be verified in the lower left panel of figure 5.3. Importantly, due to the absence of a sizeable substitution effect, demand for B_1 also increases. Residents in country 2 benefit from the improvement in the terms of trade and from the higher demand by country 1 which combine to a positive wealth effect and raise country 2's demand for intermediate goods too. In contrast to the flexprice model, intermediate producers in country 2 expand their production as the price for good B increases implying a positive cross-country output correlation. Consider then the case where ρ is assumed to be large ($\rho = 3.5$) . Here, the substitution effect dominates the wealth effects. Residents in both countries substitute away from good B to good A as shown in the lower right panel of figure 5.3. The shortfall in demand for good B triggers a decrease in country 2's output while output in country 1 still increases. This explains why the rigidprice model predicts a cross-country output correlation that decreases in ρ and eventually becomes negative.

The presence of a strong substitution effect causes country 1's exports (A_2) to rise while its imports (B_1) fall. It is for this reason that the rigidprice model predicts positive correlations between the terms of trade and net exports and output and net exports - as displayed in figure 5.1 - when ρ becomes large enough.

5.2 Empirical Evidence

Economically speaking, the business cycle in two economies displays a stronger coherence the less import goods are substitutable by domestically-produced goods. However, the models differ in their explanations how the business cycle synchronization can be accounted for. The flexprice model emphasizes the wealth effect from improvements in the terms of trade that stimulate demand and thus raise output abroad. As ρ declines, the terms of trade effect becomes stronger which explains why output is higher correlated when domestic and foreign goods are compliments rather than substitutes. As the substitution effect is relatively small, the behavior of a country's external balance is unchanged by variations in the IES. In contrast, the rigidprice model attributes the key role to the substitution effect. For small values of ρ, agents cannot substitute away from either goods, which explains why demand for importable goods increases and is thus inducing a co-movement in domestic and foreign output. As the degree of substitutability amongst domestically-produced and importable goods improves, the substitution effect becomes important and the cross-country output correlation falls. Importantly, the behavior of the net export balance relative to output is affected by changes in ρ. A strong substitution effect is characterized by sizeable shifts in demand implying a co-movement in output and net exports. The key difference between the flexprice and the rigidprice model is the extent to which the intratemporal elasticity of substitution affects the output - net export correlation.

The empirical analysis consists of two steps. Since estimates of the IES are not readily available, we begin by estimating ρ. In a second step, the estimates are related to contemporaneous correlations of output, net exports and the terms of trade in the cross-sectional dimension. Empirical studies of export and import price elasticities[37] are based on a variety of theoretical models. Nevertheless, the bulk of empirical research consensuses on some type of the imperfect substitutes model[38] that relates import and export demand to domestic and foreign output and relative price changes. The core structure

[37] The empirical literature usually refers to the price elasticity of export and import demand when referring to ρ. As noted before, we use these terms interchangeably to address the intratemporal elasticities of substitution (ESG) between domestic and foreign goods.

[38] See Hooper and Marquez (1995) and Goldstein and Kahn (1985) who survey the empirical literature of estimating import and export demand elasticities.

of import and export demand can be summarized by

$$\begin{aligned} IM_{it} &= f\left(Q_{it}, PI_{ti}, P_{it}\right) \\ EX_{it} &= g\left(Q_t^*, PX_{it}, P_t^*\right) \end{aligned} \tag{25}$$

where IM_i and EX_i denote imports and exports of country i, PI_i and PX_i represent the import and export price indices of country i, P_i and P^* refer to domestic and world price levels and Q_i and Q^* stand for domestic and world output. All variables are denominated in domestic currency units. Extended versions of (25) include various lag structures accounting for staggered price adjustment or information delays. The "bare-bone" structure (25) of the imperfect substitutes model is an integral part of both, the flexprice and the rigidprice model. In the rigidprice model, country'1 s imports and exports are related to domestic and foreign output and relative price changes by equations (13). Although less obvious, this holds analogously for the flexprice model. Here, equation (5) can be rearranged[39] to appear in a similar structure like (13). In order to obtain estimates of import and export price elasticities, empirical studies predominantly consider linearized versions of (25). We follow this standard strategy and take a log-linear approximation of the relevant export and import demand equations (13). The "hat" denotes the percentage change of a variable or, alternatively, the percentage deviation from a steady state. From country 1's perspective, B_1 and A_2 are equivalent its imports and exports and can be denoted by IM_1 and EX_1. Because the LOP and PPP are assumed to hold, P_1^b and P_2^a represent country 1's import and export price deflators PI_1 and PX_1. Foreign variables are denoted by asterix[40]. These notational conventions give rise to a representation summarized by

$$\begin{aligned} \widehat{IM}_{it} &= -\rho^{im}\left(\widehat{PI}_{it} - \widehat{P}_{it}\right) + \widehat{Q}_{it} \\ \widehat{EX}_{it} &= -\rho^{ex}\left(\widehat{PX}_{it} - \widehat{P}_t^*\right) + \widehat{Q}_t^* \end{aligned} \tag{26}$$

where ρ^{im} and ρ^{ex} refer to the export and import price elasticities. The representation by (26) allows for a separate estimation of export and import price elasticities. This strategy seems to have some flavor because imports and exports appear empirically to respond differently to relative price changes[41]. Additionally, there is a theoretical argument

[39] Simply solve equation (5) for B_1 - which represents imports by residents of country 1 - and note that A_1 is some fraction $(1-w)$ of country 1's output Q_1. Equation (5) reads then as follows: $B_{1t} = w\left(P_t^{tot}\right)^{-\rho} Q_{1t}$. The similarity to equation (13) is straightforward. One may proceed analogously to derive the export demand equation.

[40] Thus far, we assumed the perspective of a two-country world. Equally one may think of country 2 as the rest of the world or, as we will do, an weighted average of G7 countries.

[41] Hooper and Marquez (1995) report average estimated price elasticities for the G3 countries. The mean export and import price elasticities differ significantly for Japan (1.68 and 0.97) and Germany (1.06

suggesting that export and import price elasticities are different. Due to third market competition, exports are expected to be more responsive to relative price changes than imports. However the flexprice and the rigidprice model assume no difference in export and import price elasticities. Being theoretically consistent, one would have to run a pooled regression with equality restrictions that assure ρ^{ex} and ρ^{im} being equal. Both strategies have been pursued in the literature but neither qualifies ex ante convincingly as superior. Therefore, we explore the sensitivity of our results to the assumption that ρ^{ex} and ρ^{im} are different by following both strategies. To begin with, we consider the specifications

$$\widehat{IM}_{it} = \alpha_0 + \rho^{im}\left(\widehat{P}_{it} - \widehat{PI}_{it}\right) + \alpha_1 \widehat{Q}_{it} + \alpha_2 \widehat{IM}_{it-1} + e_t \tag{27a}$$

and

$$\widehat{EX}_{it} = \beta_0 + \overline{\rho^{ex}}\widehat{P}^*_t - \rho^{ex}_i \widehat{PX}_{it} + \overline{\beta_1}\widehat{Q}^*_t + \beta_2 \widehat{EX}_{it-1} + e_t \tag{27b}$$

that allow us to obtain separate point estimates for ρ^{ex} and ρ^{im}. Alternatively, we jointly estimate ρ^{ex} and $\rho^{\iota m}$ using the equation

$$\widehat{NX}_{it} = \gamma_0 + \overline{\rho^{xm}}\widehat{P}^*_t - \rho^{xm}_{1i}\widehat{P}_{it} - \rho^{xm}_{2i}\left(\widehat{PI}_{it} - \widehat{PX}_{it}\right) + \overline{\gamma_1}\widehat{Q}^*_t - \gamma_{1i}\widehat{Q}_{it} + \gamma_2 \widehat{NX}_{it-1} + e_t \tag{27c}$$

where it is implicitly assumed that export and import price elasticities are equal: $\rho^{ex} = \rho^{im} = \rho^{xm}$[42]. The term e captures the impact of other forces that are hopefully orthogonal to the set of explanatory variables. By assumption, e is normally distributed with zero mean and constant variance. As a side remark, note that the linearized equations (26) are encompassed within both specifications. However, a caveat is warranted when estimating these equations by single-equation methods. Recall that (27a - 27c) are derived from non-reduced form equations like (26). Hence a specification like (27a - 27c) may still contain feedback effects that make it subject to the simultaneity problem. In particular, (27a - 27c) obscure the simultaneous relationship of quantities and prices. A solution to the simultaneity problem is to estimate the full structural model using multi-equation methods. The prevailing practice in the literature has been to assume that supply price elasticities of exports and imports are infinite. This assumption implies that domestic and world output raise import and export demand, but leave prices unaffected.

We follow this practice and estimate equations (27a - 27c) for each G7 country using single equation methods. Prior to estimation, all variables have been HP-filtered so that

and 0.50). This evidence appears to favor a separate treatment of import and export price elasticities.

[42] The specification (27c) is a direct extention of (26) in that one analyzes consolidated net exports rather than exports and imports separately.

variables are expressed as log-deviations from the long run trend. G7 data on nominal GDP, consumer prices and export and import price deflators are taken from the IFS tapes. Because $\widehat{IM}_{it}$ and $\widehat{EX}_{it}$ are intended to capture country $i's$ total imports and exports from and to other G7 countries only, the data is derived from bilateral trade flows as available from the DOTS tape[43]. Theoretically, $\widehat{P}^*$ and $\widehat{Q}^*$ refer to changes in the world price level and world output. Since the analysis is confined to G7 countries, $\widehat{P}^*$ and $\widehat{Q}^*$ are associated with the average changes in prices and output of the seven largest economies. There seems to be no consensus in the literature how to aggregate data when constructing average price and output indices. While non-theoretical GDP weighted averages are often used, other authors like Lumsdaine and Prasad (1999) suggest a conditional variance-based aggregation. Circumventing the issue of data aggregation, we determine the weights endogenously by including all data series into the regression analysis. That is, $\widehat{P}^*$ and $\widehat{Q}^*$ are data matrices of dimension $6 \times nobs$. Consequently, $\overline{\rho^{ex}}$, $\overline{\beta_1}$, $\overline{\rho^{xm}}$ and $\overline{\gamma_1}$ stand for 1×6 vectors[44] containing coefficient estimates. To give these estimates some economic meaning, we introduce the following restrictions:

$$\begin{array}{ll} a) & \sum_{j=1/j\neq i}^{7} \overline{\rho_j^{ex}} - \rho_i^{ex} = 0 \\ b) & \sum_{j=1/j\neq i}^{7} \overline{\beta_{1j}} = 1 \\ c) & \sum_{j=1/j\neq i}^{7} \overline{\rho_j^{xm}} - \rho_{1i}^{xm} = 0 \\ d) & \rho_{1i}^{xm} = \rho_{2i}^{xm} \\ e) & \sum_{j=1/j\neq i}^{7} \overline{\gamma_{1j}} = 1. \end{array} \tag{28}$$

The restriction $a)$ and $b)$ apply to the estimation of (27b); $c) - e)$ restrict the coefficient estimates in (27c). Restriction $a)$ says that the response of a country's exports to relative price changes is equal regardless if the price movements arise from changes in the export price or the aggregate foreign price level[45]. $b)$ and $e)$ restrict the coefficient estimates such their sum is equal to one. That is, foreign output $\widehat{Q}^*$ is some weighted average of output in any G7 country, excluding country i. The restrictions $c)$ and $d)$ are comparable to $a)$. They assure that the response of a country's net export balance to relative price changes is equal regardless if the price movements arise from changes in the export and import price deflators or the aggregate domestic and foreign price levels. The rationale for the restrictions $a)$ and $c)$ is as follows: Assume for a moment that data of an average G7

[43] See appendix B for a precise description of the data employed in the regression analysis.

[44] These vectors would read as follows: $\overline{\rho^{ex}} = [\rho_1^{ex}, \rho_2^{ex}, ..\rho_6^{ex}]'$; $\overline{\beta_1} = [\beta_1, \beta_2, ..\beta_6]'$; $\overline{\rho^{xm}} = [\rho_1^{xm}, \rho_2^{xm}, ..\rho_6^{xm}]'$ and $\overline{\gamma_1} = [\gamma_1, \gamma_2, ..\gamma_6]'$.

[45] Recall equation (13) implying that demand for exports and imports reacts equally to changes in export and import prices or in aggregate price levels.

price level $\widehat{P^*}$ be available. Equation (27b) would then be estimated with the equality constraint: $\overline{\rho^{ex}} = \rho_i^{ex}$ where both are scalars. Because data on an average G7 price level is not available, we consider an akin specification of (27b) that includes price levels of individual countries:

$$\widehat{EX}_{it} = \beta_0 + \rho_1^{ex}\left(\widehat{P}_{1t} - \widehat{PX_{it}}\right) + \rho_2^{ex}\left(\widehat{P}_{2t} - \widehat{PX_{it}}\right) + ... + \rho_6^{ex}\left(\widehat{P}_{6t} - \widehat{PX_{it}}\right) + \overline{\beta_1}\widehat{Q}_t^* + ... \; . \quad (29)$$

Here, $\widehat{P_{jt}}$ stands the price level of country j, and ρ_j^{ex} refers to the price elasticity of exports with respect to country j. For convenience, some terms have been dropped from (29). This representation may be rearranged to

$$\widehat{EX}_{it} = \beta_0 + \sum_{j=1/j\neq i}^{7} \rho_j^{ex}\widehat{P}_{jt} - \rho_i^{ex}\widehat{PX_{it}} + \overline{\beta_1}\widehat{Q}_t^* + ... \; . \quad (30)$$

where ρ_i^{ex} is a scalar. To make (30) an identical representation to (27b), we need to impose the restriction

$$\left(\sum_{j=1/j\neq i}^{7} \rho_j^{ex}\right) - \rho_i^{ex} = 0 \quad (31)$$

that is implied by the algebraic transformation of (29). For interpretational purposes, the term $\sum_{j=1/j\neq i}^{7} \rho_j^{ex}\widehat{P}_{jt}$ can be conceived as linear combination of foreign price levels times the export price elasticity of country i : $\sum_{j=1/j\neq i}^{7} \rho_j^{ex}\widehat{P}_{jt} = \rho_i^{ex}\left(\sum_{j=1/j\neq i}^{7} \eta_j\widehat{P}_{jt}\right)$ where η_j is the weight by which the price level of country j enters the aggregate G7 price level. Importantly, η_j is determined endogenously for all $j = 1, ..., 6$. A similar reasoning applies to restriction c) in (28).

We are now in a position to estimate (27a - 27c) subject to the constraints implied by (28) using restricted least square estimation techniques. Table VII summarizes the point estimates for the price elasticities ρ^{im},ρ^{ex} and ρ^{xm} as well as the $R-squared$ and $DW-Statistic$ for any equation (27a - 27c). Because the focus is on empirical estimates of price elasticities, other coefficient estimates are not reported. Empirically, import price elasticities of the major G7 economies are in the range of 0.19 to 1.16 with a mean of 0.68. Point estimates of export price elasticities are consistently larger with a mean of 1.59. With 0.6 at the lower end, export price elasticities may become as large as 2.07[46]. These point estimates are positive and statistically significant for any G7 country at

[46] These estimates are in the range of previous findings as summarized by Hooper and Marquez (1995). Average estimated export price elasticities are 1.31, 1.68 and 1.06 for the US, Japan and Germany. Point estimates of import price elasticities are 1.35, 0.97 and 0.5 respectively. The confindence region - defined by the two-standard errors bounds - include all our estimates.

conventional levels. In contrast, price elasticities for net exports vary around zero and are largely insignificant. We cannot detect a statistically meaningful relationship between relative price movements and net exports for major industrialized countries.

Intratemporal Elasticity of Substitution

	Equation (27a)			Equation (27b)			Equation (27c)		
	ρ^{im}	R^2	DW	ρ^{ex}	R^2	DW	ρ^{xm}	R^2	DW
Canada	0.68*	0.23	1.96	1.85*	0.67	1.88	-0.03	0.33	1.90
France	0.36*	0.37	1.97	2.47*	0.54	1.96	0.22	0.22	1.96
Germany	1.16*	0.56	2.11	2.07*	0.50	2.00	2.07*	0.60	1.99
Italy	0.68*	0.18	1.93	0.60*	0.56	1.98	0.24	0.17	2.05
Japan	0.39*	0.76	1.65	1.12*	0.82	2.13	0.48	0.62	2.30
UK	0.92*	0.45	1.89	1.38*	0.48	1.94	-0.40	0.50	1.98
US	0.19	0.42	2.22	1.63*	0.46	1.83	0.19	0.43	2.02

Table VII) Point estimates of substitution elasticities; * denotes significance at 95 percent confidence level

The absence of strong S-curve patterns in the cross-correlation functions of figure 2.1 already insinuated this result. Part of this failure may be accounted for by employing price deflators that capture price changes in a country's total trade flows rather than in trade flows within the group of G7. Further, the evidence suggests that exports are more sensitive to relative price changes than imports. This result is consistent with earlier studies as summarized by Hooper and Marquez (1995). However, if the cross-correlation function of exports and imports are examined analogously to figure 2.1, there is no evidence that exports respond more rapidly and thoroughly to relative price changes than imports. This observation is, we think, inconsistent with the conclusions above. Overall we do not tend to preclude that export price elasticities are consistently larger than import price elasticities.

The standard deviations from the mean point estimates are 0.32 and 0.62 for the import price and export price elasticities respectively. Statistically speaking, 95 percent of the estimated import price elasticities fall in the interval $[0.04, 1.32]$; the corresponding interval for the export price elasticities is $[0.35, 2.83]$[47]. Recall from the theoretical experiment - illustrated in figure 4.6 - that variations in price elasticities between 0 and 3 are accompanied with substantial changes in co-movements of output, net exports and

[47] There is one objection to this reasoning which we are aware of: Deducing asymptotic distributions from a limited sample size of 7 observation is questionable at best. But we made this point simply to illustrate that price elasticities are sufficiently different to account for cross-country differences in important stylized facts of the business cycle.

the terms of trade. More precisely, theory predicts that increases in price elasticities trigger a fall in cross country output correlations and a rise in the correlation between the terms of trade and net exports. The impact on the output - net export correlation is ambiguous: in a flexible-price framework, net exports remain countercyclical. Under rigid prices and monopolistic competition, the output - net export correlation increases and eventually becomes positive.

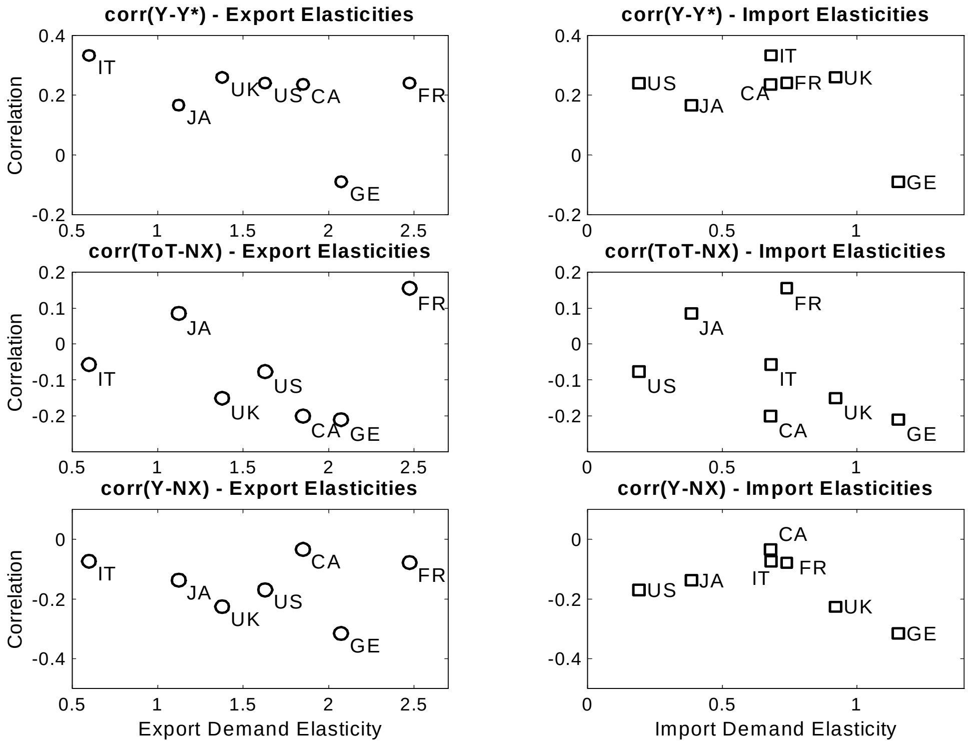

Figure 5.4: Price Elasticities and Average Correlations in G7 Countries

These predictions can be tested empirically by relating the estimated price elasticities to various correlation measures in the cross-section. However, a relatively small sample size of 7 countries is insufficient to justify the application of formal econometric methods. Nevertheless, to provide some intuition, figure 5.4 summarizes graphically the empirical relationships between price elasticities and contemporaneous correlations. The panels to the left display the impact of export price elasticities on co-movements of output, relative prices and net exports; the corresponding relationships for the import price elasticities are shown in the panels to the right. A few observations deserve attention: Although export price elasticities appear to be consistently larger than import price elasticities, no structural differences can be recognized as far as their impact on various correlations is concerned. Bilateral output correlations appear to have some tendency to decrease with ρ.

This observation is consistent with the theoretical predicts of the flexprice and rigidprice model. To the naked eye, the co-movements of output and relative prices with net exports seem to be independent from price elasticities. Overall, there is no obvious link between the intratemporal elasticity of substitution and the contemporaneous correlations of output, relative prices and net exports. The evidence for the theoretically predicted relationships is weak at best. However, we are also unable to provide counter-evidence. In the absence of formal criteria, refuting statistical relationships is difficult at best.

6 Conclusion

This paper has attempted to assess the importance of the trade channel in the international transmission of economic fluctuations. In particular, we have explored to what extent a country's openness - measured as the export/import share in domestic output - and dependence upon foreign trade - measured as the degree of substitutability between domestic and importable goods - affect the co-movements of output, relative prices and net exports. To begin with, a comprehensive set of stylized facts is provided that summarizes empirical regularities of important open-economy variables for the G7 countries. An international real business cycle model and a new-keynesian type model are calibrated to demonstrate how the level of foreign trade and the degree of import substitution affect the co-movements of output, relative prices and net exports. Subsequently, data on bilateral trade flows within the G7 countries is used to test the theoretical predictions empirically. Several results arise from this study. Empirical regularities of open-economy variables differ considerably across the major industrialized countries. Amongst others, bilateral output correlations with the G7 countries range from -0.45 at the lower end up to 0.77 at the top. Theoretically the level of foreign trade and the degree of import substitution influence the transmission of economic fluctuations across countries. These observations give rise to the hypotheses that both factors potentially account for the dispersion of stylized facts. Empirically, the level of foreign trade is shown to exert a positive and significant influence on the cross-country output correlation. That is, bilateral trade synchronizes the output cycles. Empirical estimates of export/import shares and intratemporal elasticities of substitution are shown to be sufficiently different that country-specific shocks may trigger changes in output, relative prices and the current account that differ in size and sign across the G7 countries. In contrast to theory, no systematic pattern emerges when estimates of substitution elasticities are related to various correlation measures.

Appendix A

Benchmark Parameter Values

	"Flexprice" Model	"Rigidprice" Model
Preferences		
α	-	-99
β	0.99	0.99
γ	-1.0	-1.0
η	-	-19
μ	0.34	-
κ	-	0.0075
Technology		
ρ	1.5	1.5
υ	-	1.66
θ	0.36	0.20
δ	0.025	0.025
w	0.10	0.10
ϕ	0	8
Price Staggering		
δ_p	-	0.75
δ_w	-	0.75
Forcing Processes		
Γ	$\begin{pmatrix} 0.908 & 0.088 \\ 0.088 & 0.908 \end{pmatrix}$	$\begin{pmatrix} 0.908 & 0.088 & 0 & 0 \\ 0.088 & 0.908 & 0 & 0 \\ 0 & 0 & 0.3 & 0 \\ 0 & 0 & 0 & 0.3 \end{pmatrix}$
$cov(\varepsilon, \varepsilon)$	$\begin{pmatrix} 0.0085 & 0.0022 \\ 0.0022 & 0.0085 \end{pmatrix}$	$10^{-4} \times \begin{pmatrix} 0.64 & 0.16 & 0 & 0 \\ 0.16 & 0.64 & 0 & 0 \\ 0 & 0 & 0.81 & 0.16 \\ 0 & 0 & 0.16 & 0.81 \end{pmatrix}$

Table A.I) Benchmark parameter values used in the numerical analysis

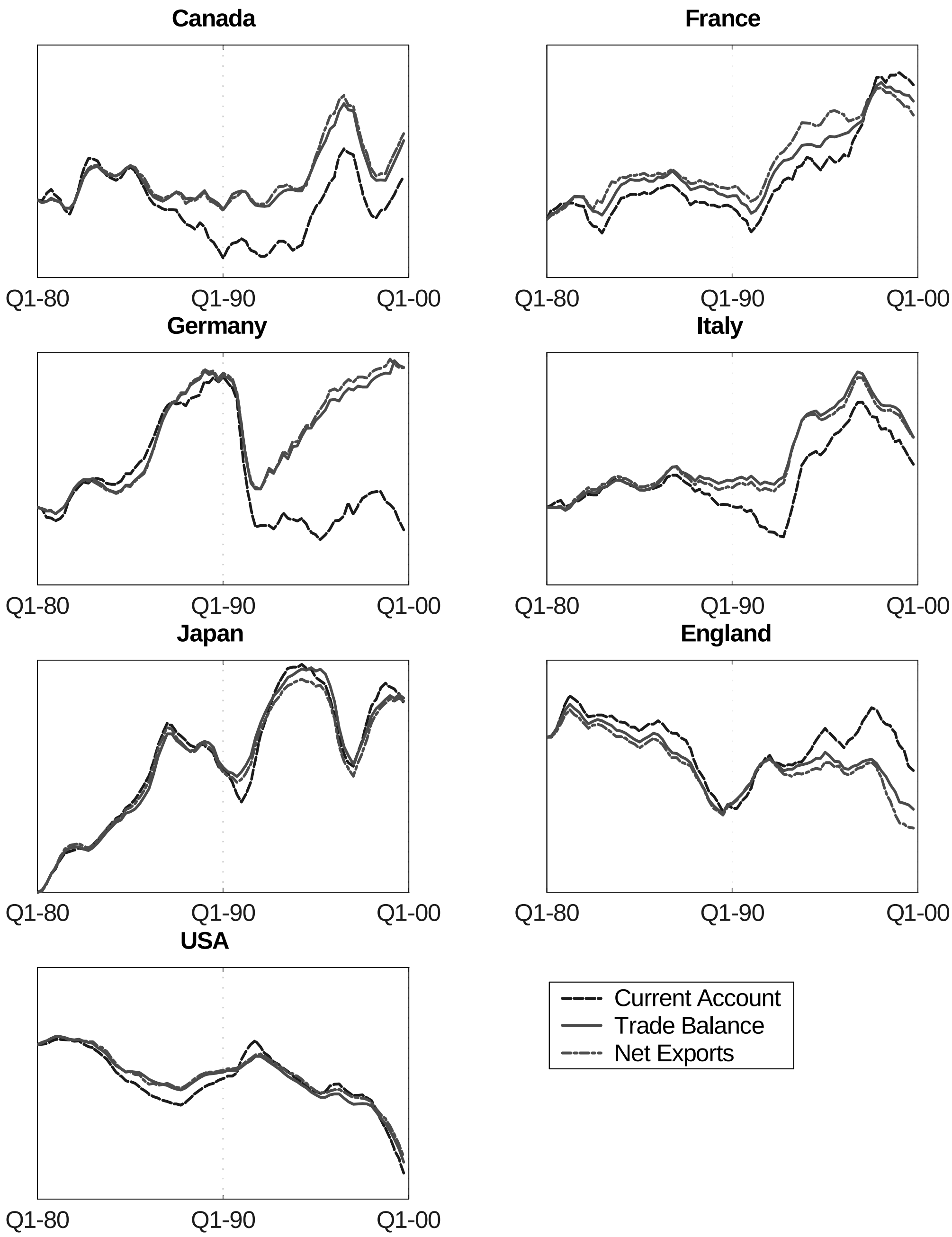

Figure A.1: Co-Movements in the Current account, the Trade Balance and Net Exports

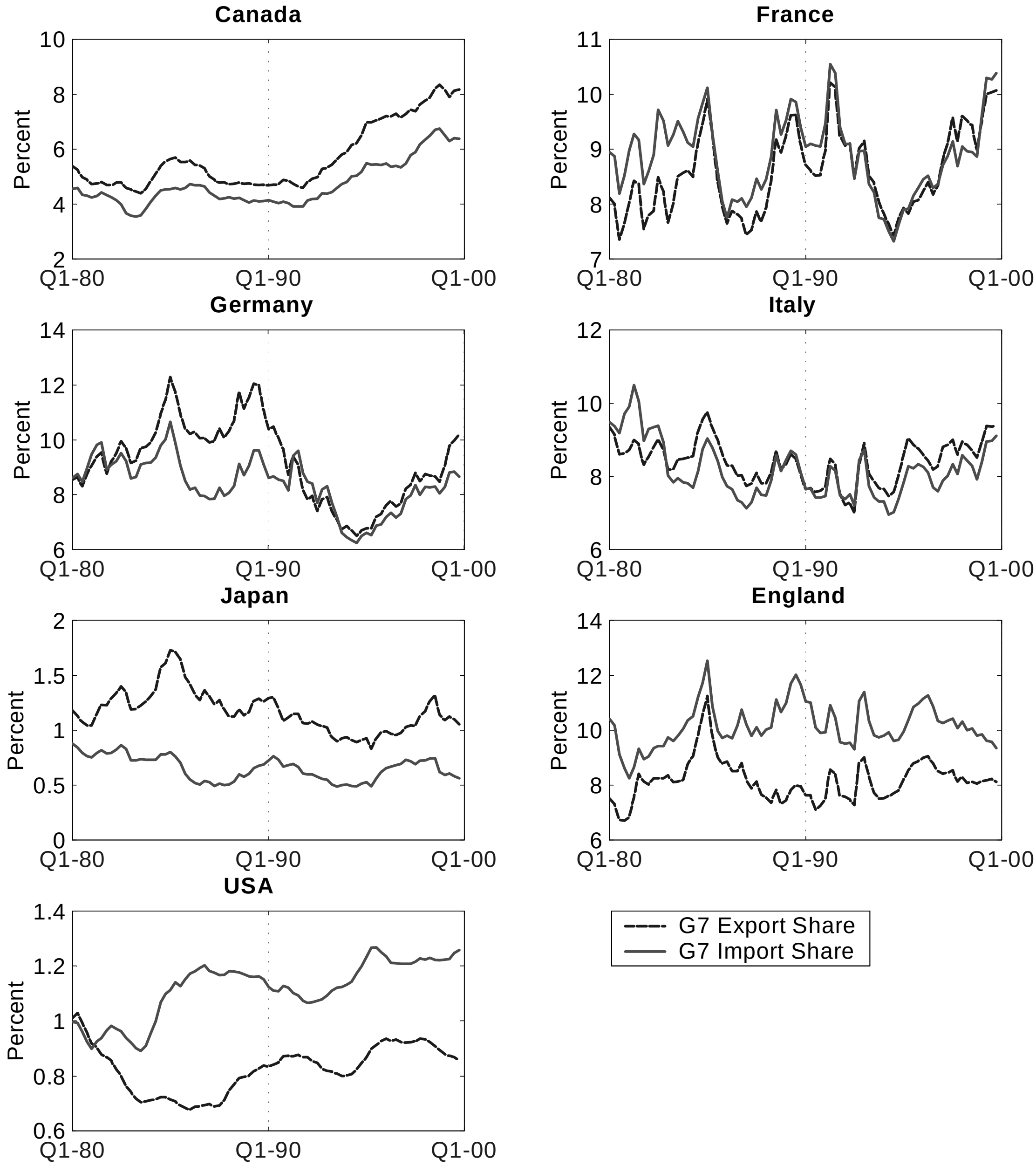

Figure A.2: Import and Export Shares over the Period 1980-1999

Appendix B

Data is taken from the International Financial Statistics (IFS) or from the Direction of Trade Statistics (DOTS). Net exports (NEX) are computed as difference of exports minus imports. Net exports within G7 countries (NEXG7) are computed as difference of total exports to all G7 (EXG7) minus total imports from all G7 countries (IMG7). A measure of the terms of trade is obtained by taking the logarithm of the import price deflator over the export price deflator. The dollar amount of bilateral exports from country k to country j are supposed to be match the bilateral imports of country j from country k. For some reasons, there are usually some deviations. Therefore, we have extracted data for bilateral imports only and derived the series for bilateral exports by imposing this equality. Data for bilateral imports that excluded the costs for insurance and freight has not been consistently available. Therefore, our data contains a "transportation cost" component.

Data Description

Variable	Code	Source	Period
Gross Domestic Product	...99B.CZF...	IFS	1980-1999
Consumer Price Level	...64...ZF...	IFS	1980-1999
Current Account	...78ALDZF...	IFS	1980-1999
Trade Balance	...78ACDZF...	IFS	1980-1999
Exchange Rate	.....RF.ZF...	IFS	1980-1999
Export Price Deflator	...74...ZF...	IFS	1980-1999
Import Price Deflator	...75...ZF...	IFS	1980-1999
Exports	...70...ZF...	IFS	1980-1999
Imports	...71.V.ZF...	IFS	1980-1999
Bilateral Exports	...71..DZD...	DOTS	1980-1999
Bilateral Imports	...71..DZD...	DOTS	1980-1999

References

Anderson, H.M., H.S. Kwark and F. Vahid (1999), *Does international trade synchronize business cycles* , Working Paper Monash University

Backus, P. Kehoe and F. Kydland (1992), *International real business cycles*, Journal of Political Economy 101, 745 - 775

Backus, P. Kehoe and F. Kydland (1994a), *Dynamics of the trade balance and the terms of trade: The J-curve,* American Economic Review 84, 84 - 103

Backus, P. Kehoe and F. Kydland (1994b), *Relative price movements in dynamic general equilibrium models of international trade,* in: van der Ploeg, F., ed., The Handbook of International Macroeconomics, (Blackwell Publishers, Cambridge)

Backus, P. Kehoe and F. Kydland (1995), *International business cycle: theory and evidence,* in: Cooley, T.F., ed., Frontiers of Business Cycle Research (Princeton University Press)

Baxter, M. (1995), *International trade and the business cycle,* in: G. Grossman and K. Rogoff, eds., Handbook of international economics, vol. 3 (North-Holland, Amsterdam)

Bayoumi, T. (1996), *International trade and real exchange rates*, in: Ito, T., P. Isaard, S. Symansky and T. Bayoumi, ed., Exchange Rate Movements and Their Impact on Trade and Investment in the APEC Region, International Monetary Fund Occasional Paper

Berk, J.M. (1997), *Trade flows as a channel for the transmission of business cycles*, Banca Nationale del Lavorro Quarterly Review 201, 187-211

Betts, C. and M.B. Devereux (2000), *Exchange rate dynamics in a model of pricing-to-market*, Journal of International Economics 50, 215-244

Canova, F. and H. Dellas (1993), *Trade interdependence and the international business cycle*, Journal of International Economics 34, 23-47

Cantor, R. and N.C. Mark (1988), *The international transmission of real business cycles*, International Economic Review 29, 493-507

Cashin, P. and J. McDermott (1998), *Terms of trade shocks and the current account*, International Monetary Fund Working Paper WP/98/177

Cole, H.L. and M. Obstfeld (1991), *Commodity trade and international risk sharing*, Journal of Monetary Economics 28, 2-24

Dellas, H. (1986), *A real model of the world business cycle*, Journal of International Money and Finance 5, 381-394

Gable, J.A. and E. Prasad (1997), *International evidence on the determinants of trade* *dynamics*, International Monetary Fund Working Paper WP/97/172

Gerlach, S. (1988), *World business cycles under fixed and flexible exchange rates*, Journal of Money, Credit and Banking 20, 621-632

Goldstein, M. and M.S. Kahn (1985), *Income and price effects in foreign trade*, in: R.W. Jones and P.B. Kenen, eds., Handbook of international economics, vol. 2 (North-Holland, Amsterdam)

Hooper, P. and J. Marquez (1995), *Exchange rates, prices and external adjustments in the United States and Japan*, in Kenen, P.B., ed., Understanding interdependence: The macroeconomics of the open economy, Princeton University Press 1995

Jensen, R.V. and D.D. Seelover (1999), *"Mode-locking" and international business cycle transmission*, Journal of Economic Dynamics and Control 23, 591-618

Kwark, N.S. (1999), *Sources of international business fluctuations: country-specific shocks or worldwide shocks ?,* Journal of International Economics 48, 367 - 385

Kollmann, R. (2001), *Explaining international co-movements of output and asset returns: The role of money and nominal rigidities",* Journal of Economic Dynamics and Control, 25(10)*,* 1547-1583

Lumsdaine, R.L. and E.S. Prasad (1999), *Identifying the common component in international economic fluctuations: a new approach,* International Monetary Fund Working Paper WP/99/154

Obstfeld, M. (1982), *Aggregate spending and the terms of trade: is there a Laursen-Metzler effect?,* Quarterly Journal of Economics 97, 251-277

Obstfeld, M. and K. Rogoff (1996), *Foundations of international macroeconomics,* The MIT Press

Phillips, K.L. (1991), *A two-country model of stochastic output with changes in regime,* Journal of International Economics 31, 121 - 142

Prasad, E. (1999), *International trade and the business cycle*, The Economic Journal , 588-606

Ravn, M.O. (1997), *International business cycle in theory and in practice,* Journal of International Money and Finance 2, 255-283

Schmitt-Grohè, S. (1998), *The international transmission of economic fluctuations: effects of U.S. business cycles on the Canadian economy*, Journal of International Economics 44, 257-287

Selover, D.D. (1999), *International interdependence and business transmission in ASEAN*, Journal of the Japanese and International Economies 13, 220-253

Stockmann, A. (1990), *International transmission and real business cycle models*, American Economic Review 80(2) , 134 - 138

Svensson, L, and A. Razin (1983), *The terms of trade and the current account: the Harberger-Laursen-Metzler effect,* Journal of Political Economy 91, 97-125

Tille, C. (2001), *The role of consumption substitutability in the international transmission of shocks*, Journal of International Economics 53, 421-44.

CFS Working Paper Series:

No.	Author(s)	Title
2001/01	**Stefanie Franzke**	Underpricing of Venture-Backed and Non Venture-Backed IPOs: Germany's Neuer Markt
2001/02	**Roland Beck**	Do Country Fundamentals Explain Emerging Market Bond Spreads?
2001/03	**Markus Kern** **Bernd Rudolph**	Comparative Analysis of Alternative Credit Risk Models – An Application on German Middle Market Loan Portfolios –
2001/04	**Antje Brunner** **Jan Pieter Krahnen**	Corporate Debt Restructuring: Evidence on Lender Coordination in Financial Distress
2001/05	**Ralf Ewert** **Andrea Szczesny**	Countdown for the New Basle Capital Accord. Are German Banks Ready for the Internal Ratings-Based Approach?
2001/06	**Bernd Kaltenhäuser**	Explaining the Dollar-Euro Rate: Do Stock Market Returns Matter?
2001/07	**Guenter Beck** **Axel A. Weber**	How wide are European borders? – New Evidence on the Integration Effects of Monetary Unions –
2001/08	**Yunus Aksoy** **Tomasz Piskorski**	Domestic Money and US Output and Inflation
2001/09	**Elke Hahn**	Core Inflation in the Euro Area: Evidence from the Structural VAR Approach
2001/10	**Olaf Ehrhardt** **Eric Nowak**	Private Benefits and Minority Shareholder Expropriation – Empirical Evidence from IPOs of German Family-Owned Firms
2001/11	**Daniel Gross**	Country-Specific and Global Shocks in the Business Cycle
2001/12	**Daniel Gross**	Trade Flows and the International Business Cycle

Copies of working papers are available at the Center for Financial Studies or can be downloaded (http://www.ifk-cfs.de).