A structural approach to measuring the degree of economic integration: Evidence from G-7 countries.

Uluc Aysun*

University of Central Florida

February, 2021

Abstract

This paper infers the degree of economic integration amongst G-7 countries by estimating a two country DSGE model separately for each country in the group. In doing so, the two economies in the model are represented by the observations for a specific country and the corresponding values for the rest of G-7. To infer the degree of economic integration, the model's shock processes are reconfigured so that they include a component that is common for each economy and shocks can be transmitted from one economy to the other. Capturing the degree of economic integration by the relative contribution of common and foreign shocks to the variation of domestic variables, the paper draws inferences that are at odds with those based on more traditional measures of globalization. Countries that are more open to trade and financial flows in the data are ranked lower in terms of economic integration according to post-estimation statistics.

Keywords: economic integration, DSGE, open economy, G-7, Bayesian estimation.

JEL Classification: E32, E44, F33, F44.

*University of Central Florida, Department of Economics, College of Business, 4336 Scorpius Street, Orlando, FL 32816. Phone: +1 (530) 574-3951, e-mail: uaysun@bus.ucf.edu.

1 Introduction

There has been an upward trend in the economic integration of advanced countries ensuing the Bretton Woods era. This trend has gained momentum in the past 20 years with the advances in information technology. Today, economic shocks, both real and nominal in nature, spill across countries at a very rapid rate and these economies sustain common global shocks at a higher frequency. An economy's vulnerability to shocks originating in other countries or in global markets depends on how integrated this economy is with the rest of the world. The level of integration, in turn, would determine the willingness of countries to participate in global policy coordination efforts. Given the growing importance of international shock transmission and common shocks and the global nature of the last two major recessions in the world, it is, therefore, important to devise measures that capture countries' degree of economic integration.

In this paper, I take a step in this direction. I use a Bayesian methodology and data from the Group of Seven (G-7) countries to estimate a medium scale dynamic stochastic general equilibrium (DSGE) model.[1] I then generate post-estimation statistics to infer the degree of economic integration for each country. Country rankings based on these statistics reveal different inferences than one would obtain from more traditional measures of globalization. For example, I find that while the United Kingdom is the most financially open G-7 economy, it is also the least and second to least integrated economy according to the two main statistics that I generate. Similarly while United States is the least open to trade, it is ranked first according to one of the post-estimation statistics. A similar disparity is observed for the other countries in the G-7. More generally, the disparity demonstrates that a more nuanced and structural approach to determining the similarity of advanced economies could provide different insights than those that can be gained from data moments.

The model that I estimate follows a Dynamic New Keynesian setup that is an extension of a Smets and Wouters (2007) type framework to an open economy setting . It, therefore, includes various nominal and real rigidities that enhance the model's ability to match responses to shocks observed in vector autoregressive models. It also includes the financial accelerator mechanism

[1] G-7 countries account for roughly a third of world output during the sample period that I analyze and they also exert a strong influence on other economies. While a better representation of world economies could be achieved by including China, most of the data that I use for estimating my model are not available for this country.

of Bernanke et al. (1999) to capture the effects of financial shocks and the role that financial frictions play in the amplification and persistence for the rest of the shocks in the model. In the basic setup, the two countries in the model are linked through trade and bond holdings that allow for international risk sharing. While these linkages allow for shocks to transmit from one economy to the other, studies show that they are not sufficient to replicate the high degree of correlation between the macroeconomic variables of advanced economies (e.g., Alpanda and Aysun, 2014) and that mechanisms are needed to generate symmetric responses to shocks across economies.

In this paper, I enhance the model's ability to capture any potential symmetry by reconfiguring its shocks processes in two ways. First, I allow for shocks to be transmitted from one country to another. I do so by estimating the correlation of the shocks across the two economies and then I use these correlation coefficients when simulating the model and generating post-estimation statistics. Second, I assume, for each shock, that there is a country-specific component and orthogonal to this, there is a component that is common across the two countries. While the latter enter the optimality conditions of the two countries symmetrically, their impact on the two economies could be qualitatively and quantitatively different. The estimation procedure reveals these potential asymmetric affects of common shocks. One could consider commodity prices, such as the price of oil, to visualize common shocks in my model. While each country could have its idiosyncratic cost push shock, exogenous changes in the price of oil (the common shock) could have systematic effects on inflation dynamics of the two countries. In my model, there are 10 country specific shocks, 3 financial, 3 demand and 4 price/productivity shocks in each country (20 total), a common exchange rate shock and 10 common shocks that correspond to the 10 country specific shocks.

One unique feature of my analysis is the bilateral approach that I follow to gauge the degree of economic integration amongst the 7 countries. I estimate the parameters governing the shock processes and the structural parameters separately for 7 country/region pairs by using quarterly data from 1997:Q1 to 2020:Q2. For example, when I use Canada to represent one of the two countries in the model, I use the rest of G-7 as the other country. Specifically, I construct 10 macroeconomic series for Canada that capture financial, demand and price dynamics in the data and then I construct the same 10 series by using data from the rest of G-7. In doing so, I exclude

Canada and I aggregate macroeconomic data across the other 6 countries or I use Gross Domestic Product (GDP) weighted averages. I repeat the same procedure for France, Germany, Italy, Japan, United Kingdom and the United States.

After estimating the model, I generate two statistics that allow me to quantify the degree of economic integration. First, I measure the contributions of all model shocks to the historical decomposition of various macroeconomic variables such as output, inflation, interest rates, employment. Historical decompositions show how much a specific shock and its lagged values drive the deviation of an endogenous variable from its steady state value for each ensuing period. After obtaining the contribution of each shock, say for Canada, I then compute the shares of common shocks and shocks that originate in the rest of G-7 to the historical decomposition of Canada's macroeconomic variables. If these shares are high, for example, I reasonably infer that Canada is highly integrated with the rest of G-7. To draw more general inferences, I also measure the average shares of common and foreign shocks across time and 9 different macroeconomic variables. These computations show that Japan and France are the most integrated economies in the G-7 with common and foreign shocks contributing nearly 50% to the macroeconomic variation in these two countries. By contrast, Canada and the United Kingdom are the least integrated, with common and foreign shocks contributing 28% and 33%, respectively.

Second, I simulate the model by using the estimated shock processes and parameter values to generate forecasts for the macroeconomic variables at different horizons. This statistic, similar in spirit to historical decompositions, captures how much shocks contribute to the future volatility of macroeconomic variables. Aggregating the contributions of common and foreign shocks to this future volatility then gives me an alternative measure of their importance. Using a one-period-ahead forecast horizon to measure forecast error variance decompositions (FEVDs), I find that common and foreign shocks have the highest shares in Japan, France and the United States. United Kingdom, Canada and Italy are at the other end of the spectrum according to this statistic.

Further analysis reveals that while financial shocks are the most important driver of macroeconomic volatility according to historical decompositions, their contributions are much smaller according to one-period ahead FEVDs. The results by type of shock also indicate that shocks have a larger impact on the variables that they are more closely associated with. For example, financial

shocks have a larger impact on net worth of entrepreneurs, interest rates and credit spreads. This relationship is more evident in FEVD statistics. I find that amongst common shocks, demand, financial, price and productivity shocks are equally important for both FEVD and HD statistics, common demand shocks albeit have the largest share during severe economic downturns. Finally, I observe that the degree of economic integration has sustained a setback after the 2008 global financial crisis as the contributions of common and foreign shocks to local business cycles have diminished for most countries.

It is important to note here that the definition of economic integration in this paper is different from macroeconomic comovement. While the latter feature can be inferred from simple correlation of macroeconomic variables across countries, identifying the importance of common shocks and foreign shock transmission requires the more structural approach that I follow. Moreover, the greater importance of common shocks and foreign shock transmission for a country does not necessarily imply a high degree of comovement between that country and the rest of G-7. For example, the effect of common shocks and foreign shocks on an economy can be much different in magnitude and direction compared to its effects on the rest of G-7, and thus these features could attenuate the degree of macroeconomic comovement. My measure also does not capture how similar economies are structurally. For example, it is reasonable to postulate that the economy of the Bahamas, while structurally different from that of the US, could be highly integrated with the US economy according to my definition.

The differences between countries that I uncover are important since G-7, whilst not having the permanent office and staff that supranational institutions such as IMF, World Bank and OECD have, meet annually and coordinate responses to economic challenges.[2] With the growing integration of economies and the global nature of business cycles, these coordination efforts have become more critical. The coordination on economic issues however has not always been a smooth process. Studies such as Lowery et al. (2019), Meyer et al. (2004), Ostry and Ghosh (2013), Truman (2004, 2019), document the conflicts that countries have had about the timing, nature and scale of responses.[3]. My findings suggest one plausible explanation for the setbacks in

[2]It should be noted that while G-20 has gained more momentum and a stronger voice following the 2008 crisis, G-7 remains the main forum for global economic affairs (see, Sobel and Goodman, 2020).

[3]It is, for example, argued that Federal Reserve liquidity swap lines were the only effective pillar of coordination during and in the aftermath of the 2008 crisis. Fiscal policy coordination was much more contentious during this

coordination. Specifically, countries such as Canada and the UK have less to gain and more to lose from policy coordination and they could benefit relatively more from independent stabilization policies. The substantial amount of cross-country policy spillover effects documented by studies such as Auerbach and Gorodnichenko.(2013) suggest that this channel could be an important obstacle to policy coordination.

My paper is closely related to the literature on the drivers of business cycles. Studies in this literature such as Clark and Shin (2000), Fernandez et al. (2017), Kamber and Wong (2020), Kose et al. (2003), Mumtaz et al. (2011), Kose et al. (2012) use empirical methodologies to compare the importance of local and international drivers of business cycles. In my paper I make a similar comparison but my analysis is different in four ways. First, while the literature mostly uses dynamic factor or Vector Autoregression (VAR) analyses, I use the structural restrictions that follow from a New Keynesian DSGE setting and a Bayesian methodology to estimate and infer the importance of different shocks. One advantage of this approach over a structural VAR analysis is that I do not have to impose any restrictions on the contemporaneous correlation of shocks. This is important as the economies that I investigate are large enough that any such restriction (through a Cholesky ordering for example), that one economy is contemporaneously unrelated to the shocks originating in the other would be implausible. Second, I approach the measurement of economic integration from a bilateral perspective as opposed to the more common multilateral approach. Specifically, for each G-7 country, I measure how integrated it is with the rest of the G-7 economies instead of measuring the commonality between the 7 countries.

Third, the approach that I follow also allows me to measure the transmission of shocks between a specific country and the rest of the G-7 bloc.[4] Therefore, while my analysis distinguishes between the common and local drivers of business cycles it adds an additional channel through which countries can be economically integrated. Finally, the New Keynesian setup that I follow allows me to consider economic integration through nominal and real variables and also accounts for the interaction between the two types of variables. By contrast, the literature mostly focuses on the comovement of either real or nominal variables. An inference from my analysis, that there has a been a decline in the degree of economic integration, is similar to that in Kose et al. (2012)

period.

[4]This transmission mechanism is similar to that in Schmitt-Grohe(1998) and Canova and de Nicolo (2003).

and Mumtaz et al. (2011), and it is at odds with Fernandez et al. (2017). It should be noted, however, that the sample periods that I use to make the comparison are very different.

My paper is also fundamentally different from the long-standing literature that introduces various frictions to open economy DSGE models to enhance their ability to generate common responses across countries. Studies such as Backus, et al. (1992), Zimmermann (1997), Obstfeld and Rogoff (2001), Ravn and Mazzenga (2004), for example, demonstrate that frictions in trade can suppress risk sharing and can generate a more symmetric response of output across countries. Kollmann (1996), Kehoe and Perri (2002), Heathcote and Perri (2002) do the same by considering frictions in asset markets. The source of friction and symmetry in Devereux and Yetman (2010), Kollmann et al. (2011), and Alpanda and Aysun (2014) is global banking. Unlike these studies, Elliott and Fatás (1996), Kose and Yi (2001), Stockman and Tesar (1995), Keller (2004) illustrate that symmetry could be generated by common technologies and real sector characteristics. Also, studies such as Christiano et al. (2018) and Linde (2018) provide an overview of the general shortcomings of DSGE models without frictions that apply to international contracts. In my paper, I do not include any frictions to international transactions that could potentially generate common shocks. I instead let the data speak and allow me to infer the size and importance of these common shocks.

2 Model

The model follows a two country DSGE framework that includes various real and nominal frictions. The components of the model are similar to those in Christiano et al. (2005), Smets and Wouters (2007), Justiniano and Preston (2010) and Bernanke et al. (1999). The approach in this paper is to combine these components. For example, the model includes the nominal and real rigidities in Christiano et al. (2005) to Smets and Wouters (2007) introduce persistence and amplification mechanisms that make the model generated responses more consistent with those obtained from standard vector autoregressive (VAR) models. The open economy features adopted from Justiniano and Preston (2010) provide endogenous channels through which shocks can be transmitted from one region to the other. As described below, I also enhance this transmission across countries through an exogenous mechanism. The financial accelerator feature of Bernanke

et al. (1999), too, introduces an amplification mechanism but also allows me to consider a richer set of financial shocks. Since I follow these frameworks closely, I defer their detailed description to Appendix A. It is useful, however, to discuss the outline of the model at this point.

The model is populated by households, entrepreneurs, intermediate good, final good and capital producers, a risk-neutral bank, labor and import intermediaries, a central bank and a government. The domestic and foreign economies are modelled symmetrically so that there is a separate set of these agents in each economy. The households maximize their life-time utility by deciding how much to consume, supply labor and save. They save by holding 1-period foreign and domestic bonds. Their labor services are hired by a labor intermediary which aggregates the labor services and supplies them to monopolistically competitive intermediate good producers. These producers also rent capital from risk-neutral entrepreneurs and sell their products at a mark-up to perfectly competitive final goods producers who in turn aggregate all intermediate goods to produce the final good in the economy.

The entrepreneurs, the bank and capital producers behave and interact with each other according to the financial accelerator mechanism of Bernanke et al. (1999). Specifically, the entrepreneurs use their net worth and funds borrowed from the bank to purchase investment goods, they then supply these goods to capital producers who in turn use these goods and the previous period's undepreciated capital to produce new capital goods. Entrepreneurs do face an idiosyncratic returns to capital shock that can cause these agents to default on their loans to the bank if it is sufficiently low. In this event, the bank collects all the capital the defaulting entrepreneurs possess but they pay a monitoring cost. This friction generates a wedge between the risk free rate and the external cost of capital for the entrepreneurs that in turn depends on their financial leverage.

Monopolistically competitive import intermediaries purchase import goods in foreign currency, they differentiate these goods and sell them to an import aggregator who combines them into a uniform import good. The central bank in each region sets the policy rate, also the risk free rate in the economy, by following a Taylor rule. The government in the economy issues bonds and collects taxes to finance its expenditures.

The price and wage setting behavior in the model is characterized by nominal rigidities and

the model also includes real rigidities such as external habit formation, capital utilization and investment adjustment costs. Finally, in each region there are ten types of shocks that are introduced through the demand, supply and the financial sides of the economy. These shocks are the focal point of my analysis and I describe them in detail below.

3 Data and estimation methodology

I estimate the model described above separately for each G-7 country. To do so, I first obtain 11 quarterly data series (the observables) that span the 1997Q1-2020Q2 sample period for each country from the Federal Reserve Bank of St. Louis, FRED database. These data describe the real, financial and demand sides of the economies and they include gross domestic product, consumption, investment and government expenditures, import price index, the GDP deflator, overnight interbank interest rates, wage rate, number of employed, stock market index and nominal exchange rate (US Dollar per national currency). The definitions of the variables are provided in Table B.1 of Appendix B.

Next, for each country I construct the corresponding data series (with the exception of exchange rates) for the G-7 bloc that excludes that country. For example, when estimating the model with France representing the domestic economy, the observables for the foreign economy are constructed by using data from the G-7 bloc that excludes France. To compute the GDP, consumption, investment and government expenditures of the G-7 bloc that excludes France, I measure these variables as real US dollars and compute the total across the six countries. For the index variables, wages, domestic prices, stock market index and for interest rates, I use the GDP (in real US Dollars) of the six countries as weights to obtain the G-7 bloc variables as weighted averages. To obtain import price indices for the group of countries excluding France, I first measure each country's imports in both real and nominal US Dollars, I then add these variables to obtain the total amounts for the six countries. Finally, I measure import price index as the ratio of the two variables, nominal and real imports. Repeating these procedures for the other countries, I obtain 7 different datasets that characterize the 7 pairs of domestic and foreign economies described above.

For each of the 7 pairs, a total of 21 quarterly data series are used to estimate the structural

parameters and the parameters governing the shock processes of the model. Prior to estimation, all data series are seasonally adjusted, demeaned and log-differenced with the exception of interest rates that are linearly detrended. The model features 10 shocks for each region, consumption, investment, government spending, total factor productivity, domestic price, import price, wage, monetary policy, credit spread, net worth shock and a common depreciation shock.

An important aspect of my analysis is that the shocks processes in the model are enhanced in two ways to facilitate the analysis and measurement of economic integration. The first enhancement is the introduction of common shocks. Specifically, I assume, for each shock, that there is a country/region specific component and a common component that affects the two regions symmetrically. For example, let $\varepsilon_{a,t}$ and $\varepsilon^*_{a,t}$ represent total factor productivity (TFP) shocks that originate in the economies of Canada and the rest of G-7, respectively. I reconfigure these shocks as follows:

$$\varepsilon_{a,t} = \varepsilon^{CA}_{a,t} * \varepsilon^{common}_{a,t} \tag{1}$$

$$\varepsilon^*_{a,t} = \varepsilon^{G7}_{a,t} * \varepsilon^{common}_{a,t} \tag{2}$$

where $\varepsilon^{common}_{a,t}$ represents the component of the shock that is common across the two regions, and the terms with the CA and $G7$ superscripts denote the region specific shocks. In discussing model inferences, I will associate the importance of common shocks with economic integration. If a country's business cycles are driven mostly by common shocks, for example, I will reasonably designate this country as economically integrated.

Second, I allow region specific shocks to be correlated to further enhance the model's ability to capture global interdependence. More specifically, I estimate the correlation of shocks across the two economies and I incorporate the estimated correlation coefficients to compute statistics and draw inferences from the model. According to this mechanism a shock that originates in one region is transmitted to the other contemporaneously depending on the sign and size of the correlation coefficient.

These two features reinforce the model's inter-economy linkages through trade and bond holdings and they allow me to capture the degree of economic integration more comprehensively. Shocks in the economy, common and country specific, are orthogonal to each other by design and

I assume that they follow an AR(1) process.

To obtain quantitative inferences, I first log-linearize all variables so that they represent deviations from their steady state values. I then estimate the model. The main advantage of estimating the model over calibrating it is that it allows me to use data and the model structure to determine the relative persistence and volatility of shocks. These relative values are key as they will determine which shocks are more important for business cycles and they will allow me to gauge the degree of economic integration. The procedure also allows me to account for the uncertainty about parameter values when computing post-estimation statistics. Both of these are not possible when a more conventional calibration exercise is used. To estimate the model, I use a Bayesian methodology. In general, this methodology follows the steps in Blanchard and Khan (1980) to obtain a reduced form of the model from its state space representation. The predetermined variables in the model are linked through measurement equations to their corresponding values in the data (i.e., the observables described above). A Kalman filter is then used to form a likelihood function that includes the parameters' prior distributions and the observed values of the variables. As a final step this likelihood function is maximized to obtain posterior density functions of the parameters. To derive this density function, I use a Markov Chain Monte Carlo simulation.[5]

The prior and posterior distributions for both the structural and shock parameters of the model are displayed in Appendix B, Table B.2. The table reports the results separately for each of the 7 estimations and it also displays the estimated values for the correlation coefficients mentioned above. In fixing prior distribution parameters and functions, I follow common practice (e.g. Smets and Wouters, 2007 and Gilchrist et al., 2009). I do the same when setting the values of the level parameters of the model. These parameters are not estimated as their values can be derived from the mean values of the observables that are demeaned prior to estimation. The level parameters and their corresponding values are discussed in Appendix B. It should be noted here, however, that the level parameters are fixed, separately for each of the seven domestic and foreign economy pairs, so that the steady state GDP shares of consumption, investment and government spending is consistent the corresponding values in the data. The considerable difference between the prior and posterior values of the parameters in general indicate the data that are used to

[5]I use Dynare to estimate the model and to compute some of the post-estimation statistics. As an estimation routine, I use mode_compute=6.

estimate the model are fairly informative. I should also note that the strength of identification in my estimation could potentially be diminished by the fact that number of observables is less than the number of shocks. I do, however, find that the Fisher information matrix, calculated by following the methodology of Iskrev (2010), is full rank for all seven estimations and therefore there I don't find any evidence for weak identification of structural and shock parameters.

Before I proceed, it is important to describe the shocks in the model as they are the primary source of economic integration in my analysis. On the demand side, investment shock can be interpreted as an exogenous change in the investment-specific technology. In Greenwood et al.(2000), for example, this shock represents a multi-factor productivity shock to the production of equipment and machinery. Positive values of this shock indicate a higher conversion rate of investment to capital production which in turn prompts higher investment demand. Consumption shock in the model affects households' intertemporal consumption decisions. Faced with a positive consumption shock, for example, households cross-subsidize today's consumption by using tomorrow's consumption. Finally, the model includes a government spending shock that captures the effects of fiscal policy and any crowding out effects that it may have on other components of demand. This shock is introduced through the resource constraint of the economy.

Turning to the financial side, a net worth shock can be interpreted as an exogenous change in the survival rate of entrepreneurs. If the shock is positive, this implies a higher level of net worth, lower financial leverage and lower credit spreads via the standard financial-accelerator mechanism. Lower credit spreads in turn increase investment and overall demand in the economy. The interest rate shock represents changes in monetary policy and following common practice it is included in the Taylor rule. The last financial shock is an exogenous change in credit spreads. This shock is commonly interpreted as an exogenous change in the idiosyncratic returns that entrepreneurs face. More specifically, the shock affects the credit spreads that entrepreneurs face by changing the standard deviation of their idiosyncratic returns to capital shock.

On the supply side, the model features a standard disembodied productivity shock that is included in a Cobb-Douglas production function. There are three types of cost-push shocks, wage, domestic and import price shocks, that can be interpreted as an exogenous change in the mark-up rate of workers, intermediate goods producers, and importers, respectively.

Finally, the model includes an exchange rate shock that, for positive (negative) values, represents an increase (decrease) in the risk of holding domestic bonds relative to foreign bonds.

4 Results

In this section, I report the historical and forecast error variance decompositions for the main macroeconomic variables in the estimated model and I compare the inferences that I obtain from these statistics with those obtained from more traditional measures of economic globalization.

4.1 Historical Decompositions

To gauge the degree of economic integration, I begin by investigating the historical decompositions of the main macroeconomic variables in the model. After estimating the two country model for each nation as explained above (e.g., Canada and the rest of G-7), I reasonably assume that a nation is more economically integrated if foreign shocks (shocks originating in the rest of G-7) and shocks that are common to G-7 countries explain a greater share of the historical variation in macroeconomic variables of that nation. These shares are represented by historical decompositions that capture the contribution of each shock to the historical deviation of endogenous variables from their steady state values.

The historical decompositions measured for output growth are displayed in Figures 1 through 5 and they are summarized for the main macroeconomic variables in the model in Tables 1 and 2. In Figures 1 and 2, the historical decompositions are displayed with and without observations for 2020, respectively, given that there is a very sharp decline in output of all 7 countries during this year. The two figures generally demonstrate the importance of domestic shocks for output volatility as the contributions of domestic shocks constitute the largest share for most of the periods. The contribution of domestic shocks are, for the most part, in the same direction as output. This, by definition, implies that current and past values of domestic shocks drive the deviations of output from its mean value. The same observation cannot be made for foreign and common shocks. In fact, if we exclude 2009 and 2020, foreign and common shocks' contributions are often in the opposite direction of the contributions of domestic shocks. By contrast during the two severe recession periods, all three types of shocks have had a negative impact on output.

The same cannot be said about the periods with positive output growth for the 7 countries. These findings suggest that common and foreign shocks, whilst amplifying the negative response of output during severe recessions, often have a stabilizing effect on output otherwise. This is especially true if exchange rate shocks are classified as common shocks. I should note, however, that the contributions of exchange rate shocks are relatively smaller for most country-quarter pairs.

The central focus in this paper is on quantifying the degree of macroeconomic integration. To this end, I measure the contributions of domestic, common and foreign shocks to the variation of not only output but also the other macroeconomic variables in the model. These contributions are summarized in Table 1. The figures in the table are computed as follows: First, I calculate the absolute value of the total contribution of domestic shocks to the macroeconomic variables listed in the first column of the table. I do this for each period by adding up the contribution of the ten domestic shocks and taking the absolute value of this summation. Next, I repeat the procedure for foreign and common shocks. For each type of shock (domestic, foreign and common), I then compute the sum of all the contributions (in absolute value) that these shocks have made across time to infer their overall contribution. The figures reported in the table represent the shares of these overall contributions in the total amount of contributions made by the three types of shocks.

By following this methodology, I am able to determine the relative quantitative significance of the shocks regardless of whether they are amplifying or mitigating the macroeconomic variables. For example, if a shock's contribution to the variation in consumption is 2% in one period and -2% the next period, its average quantitative effect is reasonably computed as 2% and not 0% according to my methodology.

The summary statistics in the table indicate that overall, Canada has the least integrated economy followed by that of United Kingdom. This is a surprising result since, as I document below, Canada's economy is the second highest in terms of trade openness and the United Kingdom is the highest in terms of financial globalization. At the other end, France and Japan are the most integrated economies according to my estimations with more than half the contributions accounted by foreign and common shocks. Notice that these inferences are made for the average contributions across the different macroeconomic variables. If we consider only consumption and

labor, variables that commonly enter welfare calculations, the inferences remain the same. It is important to note however that policymakers and researchers who value/weigh these variables differently could obtain different rankings in terms of economic integration. For example, in terms of a central bank loss function that only includes output and domestic inflation, Italy would be ranked second behind Canada as the least integrated economy.

Turning to specific variables, I find that the G-7 countries in general are least integrated with each other in terms of consumption and net worth, and that besides import price inflation, there is no clear candidate for the highest level of integration.

If one follows a narrower definition of economic integration by focusing solely on the share of common shocks, the United States is the most integrated. Foreign shocks for this country, however, are the weakest driver of macroeconomic variables. Common shocks are considerably more important compared to foreign shocks also for France and the United Kingdom. For the other four, countries the contributions of the two types of shocks are similar in magnitude. The comparison of the contributions of common shocks to the different variables also does not reveal a clear winner in terms of economic integration.

I proceed by classifying the shocks as demand, financial, and productivity and price shocks and repeating the procedure outlined above to reproduce the summary statistics in Table 2. To obtain the total contribution of demand shocks, I add domestic, foreign and common consumption, government spending and investment shocks. Similarly, all (domestic, foreign and common) net worth, interest rate and credit spread shocks are combined to obtain the total contribution of financial shocks to the historical decomposition of the variables listed in the table. Finally, all wage, price and productivity shocks are combined to obtain the contributions of price and productivity shocks. The results in the table indicate that financial shocks are the primary driver of the macroeconomic variables in the model for every country except the United Kingdom. This is especially true for interest rates and net worth. Similarly, price and productivity shocks have a larger impact on wages, inflation and labor for most countries. For the demand side variables, I observe that while demand shocks are more important for consumption, financial shocks are the main driver of investment demand.

In Figures 3 through 5, I take a closer look at the composition of common shocks by reporting

the historical decomposition of output that can be attributed to common demand, financial, and productivity and price shocks. The results here are similarly obtained by estimating the two country model separately for each country listed in the figures and using the rest of G-7 as the foreign economy. In Figure 3, I observe that while demand shocks have been the major common driver of the sharp downturns in 2009 and 2020, common financial, and productivity and price shocks have been just as important for the historical variation of output. The figure also shows that for considerable number of country-quarter pairs the contribution of common financial and demand shocks have opposite signs. From Figure 4, I infer that this could be due to the common stabilization efforts of G-7 central banks as countercyclical interest rate shocks are the major component of financial shocks for the country-year pairs mentioned above. Amongst the three different financial shocks, interest rate shocks are the most important source of financial commonality of United States, United Kingdom, Canada and Japan with the rest of G-7 economies. Same can be said about net worth shocks for Italy and France, and credit spread shocks for Germany.

Turning to the relative contributions of common demand shocks, depicted in Figure 5, I generally observe that government spending, investment and consumption shocks are all important sources of commonality in the G-7 bloc. There are, however, differences across countries. While common consumption shocks are relatively more important in the US and France, common investment shocks have made larger contributions to output variation in Canada and Germany and to a lesser extent in Italy. Also common government spending shocks appear to be a more important driver of output volatility in Japan and the UK.[6]

4.2 Forecast Error Variance Decompositions

I proceed by summarizing the forecast error variance decompositions (FEVD) that are obtained from the 7 different estimations of the model. FEVD measures the contribution of each shock to the variance of the forecast errors for model variables. Here, forecast errors are generated by smoothed shocks that represent the best estimate for the shock values and they are computed for different forecast horizons. It is important to note that while historical decompositions indicate

[6] In Appendix C, I also report to average contributions of each shock (all 30 shocks) to the historical decompositions of macroeconomic variables in each country.

the contribution of shocks to the entire history of business cycles, FEVD measures these contributions for specific horizons, say 1 quarter ahead. Nevertheless, I compute and analyze FEVDs as they are a long-standing and commonly used tool to determine the drivers of business cycles in macroeconomics (e.g., Gali, 1999; King et al., 1991).

I report the FEVDs that I obtained from the different 7 estimations in Tables 3 to 5. The main inferences from Table 3 are similar to those obtained from the historical decompositions in Table 1. The variance decomposition of one quarter ahead forecasts displayed in the table similarly reveal the high share of domestic shocks for Canada, Italy and the United Kingdom. Also similarly, these shocks are relatively less important for Japan and France. Unlike earlier results, however, domestic shocks do drive a larger share of macroeconomic fluctuations for Italy. In general, interest rates and investment are relatively more driven by foreign and common shocks. Similar to earlier evidence, domestic shocks have a high contribution to the FEVD of consumption and net worth. These results are very similar to those obtained by using a 10 quarter forecast horizon. Table 4 reports the FEVD statistics that correspond to this longer horizon. It should be noted that common shocks' contributions are slightly smaller for most variables and that the contributions of domestic shocks are noticeably higher for most countries at the longer horizon.

Turning to the FEVDs by demand, financial, and price and productivity shocks, the results reported in Table 5 show that financial shocks' contribution to general macroeconomic volatility is much smaller compared to their contribution to historical decompositions. Also, the relatively larger effects of demand shocks on output and consumption, financial shocks on net worth and interest rates and price and productivity shocks on inflation and labor is more clearly observed in the FEVD statistics. In contrast to the inferences from historical decompositions, investment demand is mainly driven by demand shocks according to FEVDs.

4.3 An assessment of economic integration

The top panel of Table 6 reports some indicators of economic integration for the G-7 countries. The first two rows show the two statistics that approximate trade and financial openness. According to these statistics, Germany and Canada are the most open to trade, and UK and France are the top two financially open economies. US and Japan are at the other end of the spectrum for both

variables. The country rankings for these two integration indicators are listed in the middle panel of the table. It is important to note that the correlation between the two openness ratios are quite low (with correlation coefficient of 0.11) as displayed in the bottom panel. This observation highlights the importance of a more nuanced approach, as this paper attempts to do, to measuring the integration of economies with the global economy.

The rest of the top panel displays the shares of foreign and common shocks in the HDs and FEVDs of the seven countries. The countries are also ranked in terms of these two statistics in the middle panel. As mentioned above, while Canada, Italy and the UK have a low integration with the rest of G-7 economies according to these statistics, France and Japan (and the US in terms of FEVD) have a high degree of integration.

The bottom panel shows that the model generated statistics are negatively correlated with the two openness measures. These statistics are positively and highly correlated, albeit with a correlation coefficient considerably less than 1. The disparity between the inferences drawn from the model and data, and the low correlation between the two commonly-used indicators of globalization, in more general terms, suggest that a country's exposure to and commonalities with the rest of the world cannot be determined accurately from a single data moment.

The top panel also shows that with the exception of Japan, the relative importance of common and foreign shocks for countries is similar across the HD and FEVD statistics. There is no clear indication of which type of shock is more important as some countries have a higher share of foreign shocks and the others have a higher share of common shocks. I should note, however, that the correlation between the shares of common shocks to HDs and FEVDs is much higher (with a correlation coefficient of 0.84) compared to that corresponding to foreign shocks (with a correlation coefficient of 0.37). Analyzing the pre-2008 and post-2009 periods, I also find that there was a setback to the integration of the G-7 countries as foreign and common shocks have generally made a smaller contribution to the variation of macroeconomic variables in the latter period.

As mentioned above, the scope of my analysis goes beyond measuring macroeconomic co-movement. While this comovement can be inferred from correlations of macroeconomic variables, identifying the significance of foreign and common shocks for local business cycles requires a struc-

tural analysis similar to that in this paper. The inferences in my paper are also different from those that can be obtained from the correlations of macroeconomic variables. The correlation coefficients reported in the top panel for output, inflation and net worth, for example, indicate that US output has the lowest correlation with the output of the rest of G-7. By contrast, US is the most integrated economy according to the FEVD statistic. Similarly, while Canada is one of the least integrated economies according to my results, correlations of output, inflation, and net worth indicate otherwise. A similar disparity is observed for Japan.

As a final step, I approach economic integration from a different perspective by measuring the HDs and FEVDs of the G-7 countries. Specifically for the seven estimations of the model, I measure the impact of a country's shocks on the economies of the G-7 bloc that excludes this country. I do this for the nine main macroeconomic variables displayed in the previous tables and then report the average contribution of shocks across the nine variables. These average values are reported in Table 7. The value of 0.5782 reported for G-7 w/o Canada, for example, represents the average contribution of shocks that originate in the G-7 bloc that excludes Canada to the historical volatility in this region. The rest of the contribution, 0.4218, comes from shocks that either originate in Canada or shocks that are common across Canada and the remaining six countries. The last three columns repeat the same procedure to summarize FEVDs obtained by using a ten quarter forecast horizon.

The G-7 specific shock column by definition reveals the importance of shocks that are neither in common nor induced by the corresponding country listed in the first column. If the figures reported under this column are large this would suggest that the cross-country spillover of shocks and the commonality of shocks are insubstantial. Conversely, smaller percentages would indicate a higher degree of economic integration for the country that is excluded. The general inference from the historical decompositions is that about half of the variation in the G-7 macroeconomic variables is prompted by common or external shocks. According to this exercise, the US ranks the highest and Canada ranks the lowest in terms of economic integration. The FEVD statistics in the last two columns demonstrate a higher degree of economic integration for all the countries as the share of FEVD due to other shocks is higher for each country that is excluded. These statistics indicate that the UK and Japan are the most and least economically integrated.

I should note here that this difference between the FEVD and HD statistics is due to their definition. HDs consider the cumulative effects of shocks. The contribution of an investment shock on output variation in 2009 quarter 4, for example, includes the impact of all the investment shocks from the beginning of the sample period (1997) up to 2009 quarter 4. By contrast, the contribution of the same shock to the FEVD of output, with a ten quarter forecast horizon, is due to investment shocks from 2007 quarter three to 2009 quarter four. This is because FEVD measures the contribution of the shocks that occur between today and the forecast horizon, to the forecast error at this horizon. The higher degree of integration inferred from the FEVD statistics then implies that while common and external shocks have a larger impact in the short term, G-7 shocks have a more sustained effect on the variation of G-7 variables.

5 Conclusion

I this paper, I infer the degree of economic integration amongst G-7 countries by estimating a two country DSGE model separately for each country in the group. To do so, I construct 7 different datasets in which the observations for a specific country and those for the rest of G-7 represent the dynamics governing the domestic and foreign economies in the model. Using post-estimation statistics, I infer that Canada, United Kingdom are relatively less and Japan and France are relatively more integrated with the rest of the group. I obtain this inference by measuring the contribution of common and foreign shocks to the historical and forecast error variance decompositions of various macroeconomic variables. My rankings of countries based on economic integration are different from the rankings based on more traditional measures of economic globalization. Canada and United Kingdom, the most global in terms of trade and asset holdings in the data are ranked amongst the lowest in terms of economic integration according to model's post-estimation statistics. The results further indicated that the common shocks to the demand, financial and real sides of the economy are equally important for economic integration and that there has been a setback in the degree of integration in the aftermath of the 2008 global financial crisis for most countries.

A natural way to proceed with this line of research is to broaden to set of countries. One could, for example, consider the group of 20 (G-20) countries. The challenging part about doing

so would be that the two country framework used in this paper would not be a good fit for the smaller economies in the group. Using two separate models to identify the importance of common shocks and foreign shock transmission could confound the analysis as it would be difficult to determine whether any differences between large and small open economies are generated by the assumptions of the different models or by country-specific factors.

A more specific direction for future research could be to apply my analysis to gauge the pros and cons of fiscal policy coordination. In particular, it could be interesting to determine whether countries are net winners or losers from joint fiscal policies. For example, when countries weigh the pros of a joint fiscal expansion with the cons of a corresponding debt overhang, are they net winners or losers. Ranking countries according to how much they benefit from this joint effort can then shed light on why some countries are less willing to participate in fiscal policy coordination during global economic downturns.

My paper takes an agnostic view on the rest of the world (partly due to the lack of data, especially for China) when investigating the economic integration of G-7 countries. Specifically, if there is any shock originating in the rest of the world, this would be picked up by the common shock processes in my model. It would be insightful to extend my analysis to a three country framework, where the third country represents the rest of world. One could use data from the remaining G-20 countries and a methodology similar to that in this paper to construct a dataset that could help approximate the macroeconomic dynamics outside of G-7. In similar spirit, it could also be interesting to apply the methodology in this paper to compare the relative integration of European Monetary Union countries with other regions that are contemplating a monetary union.

6 Supplementary material

The links to Appendix A, Appendix B and Appendix C are given below

Appendix A, Appendix B, Appendix C.

References

[1] Alpanda, S., Aysun, U., 2014. "International transmission of financial shocks in an estimated DSGE model," Journal of International Money and Finance, 47, 21–55.

[2] Auerbach, A.J., and Y. Gorodnichenko. 2013. "Output Spillovers from Fiscal Policy." American Economic Review, 103 (3): 141-46.

[3] Backus, D., Kehoe, P., Kydland, F., 1992. "International real business cycles," Journal of Political Economy, 101, 745–775.

[4] Bernanke, B. S., Gertler, M., Gilchrist, S., 1999. "The Financial Accelerator in a Quantitative Business Cycle Framework," in Handbook of Macroeconomics vol. 1C, ed. by J.B. Taylor and M. Woodford, 1341-93. Amsterdam: Elsevier Science, North-Holland.

[5] Blanchard, O., Kahn, C., 1980. "The Solution of Linear Difference Models under Rational Expectations," Econometrica, 48, 1305-1311.

[6] Canova, F. and de Nicolo, G., 2003. "On the sources of business cycles in the G-7," Journal of International Economics, 59(1), 77-100.

[7] Christiano, L.J., Eichenbaum, M., Evans, C.L., 2005. "Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy," Journal of Political Economy, 113, 1-45.

[8] Christiano, L.J., M.S. Eichenbaum, M. Trabandt, 2018. "On DSGE models," Journal of Economic Perspectives, 32(3), 113–140.

[9] Clark, T.E. and Shin, K., 2000. "The Sources of Fluctuations within and across Countries," In Intranational Macroeconomics, G.D. Hess and E. van Wincoop, eds. Cambridge: Cambridge University Press, 189-217.

[10] Devereux, M.B., and Yetman, J., 2010. "Leverage constraints and the international transmission of shocks," Journal of Money, Credit and Banking 42, 71–105.

[11] Elliott, G., and Fatas, A., 1996. "International business cycles and the dynamics of the current account," European Economic Review, 40(2), 361-387.

[12] Andrés Fernández, A. S. Schmitt-Grohé, M. Uribe, 2017. "World shocks, world prices, and business cycles: An empirical investigation," Journal of International Economics, 108(1), s2-s14.

[13] Galí, J., 1999. "Technology, Employment, and the Business Cycle: Do Technology Shocks Explain Aggregate Fluctuations?" American Economic Review, 89, 249-271.

[14] Gilchrist, S., Ortiz, A., Zakrajsek, E., 2009. "Credit Risk and the Macroeconomy: Evidence from an Estimated DSGE Model," mimeo, Boston University.

[15] Greenwood, J, Hercowitz, Z. and Krusell, P., 2000. "The role of investment-specific technological change in the business cycle," European Economic Review 44, 91-115.

[16] Iskrev, N., 2010. "Local Identification in DSGE Models," Journal of Monetary Economics, 57, 189-210.

[17] Justiniano, A., and Preston B., 2010. "Monetary Policy and Uncertainty in an Empirical Small Open Economy Model," Journal of Applied Econometrics, 25, 93-128.

[18] Kamber G., Wong, B., 2020. "Global factors and trend inflation," Journal of International Economics, 122, 103265.

[19] Heathcote, J., Perri, F., 2002. "Financial Autarky and International Business Cycles", Journal of Monetary Economics, 49(3), 601-627.

[20] Kehoe, P. and Perri, F., 2002. "International Business Cycles with Endogenous Incomplete Markets," Econometrica, 70(3), 907-928.

[21] Keller, W., 2004. "International Technology Diffusion," Journal of Economic Literature, 42, 752–782.

[22] King, R., C. Plosser, J. Stock, M.Watson, "Stochastic Trends and Economic Fluctuations," American Economic Review 81 (1991), 819–40.

[23] Kollmann, R., 1996. "Incomplete Asset Markets and the Cross-Country Consumption Correlation Puzzle," Journal of Economic Dynamics and Control, 20, 945-961.

[24] Kollmann, R., Enders, Z., and Muller, G., 2011. "Global banking and international business cycles," European Economic Review, 55, 407-426.

[25] Kose, M.A., Otrok, C., and Whiteman, C.H., 2003. "International Business Cycles: World, Region, and Country-Specific Factors," American Economic Review, 93(4), 1216-39.

[26] Kose, M.A., Otrok, C., and Whiteman, C.H., and Prasad, E., 2012. "Global Business Cycles:Convergence or Decoupling?" International Economic Review, 53(2), 511-538.

[27] Kose, A., and Yi, K., 2001. "International Trade and Business Cycles: Is Vertical Specialization the Missing Link?" American Economic Review, Papers and Proceedings, 91, 371–375.

[28] Linde, J., 2018. "DSGE models: Still useful for policy analysis?" Oxford Review of Economic Policy, 34(1-2), 269-286.

[29] Lowery, Clay, Nathan Sheets, and Edwin Truman. 2019. "International Coordination of Financial and Economic Policies," In: First Responders: Inside the US Strategy for Fighting the 2007-2009 Global Financial Crisis, eds. Ben S. Bernanke, Timothy F. Geithner, and Henry M. Paulson, Jr., with J. Nellie Liang. New Haven: Yale University Press.

[30] Meyer, Laurence H., Brian M. Doyle, Joseph E. Gagnon, and Dale W. Henderson. 2004. "International Coordination of Macroeconomic Policies: Still Alive in the New Millennium?" in The IMF and Its Critics: Reform of Global Financial Architecture. David Vines and Christopher Gilbert, eds. Cambridge, UK: Cambridge University Press.

[31] Mumtaz, H., Simonelli, S., and Surico, P., 2011. "International comovements, business cycle and inflation: A historical perspective," Review of Economic Dynamics, 14(1), 176-198.

[32] Obstfeld, M., Rogoff, K., 2001. "The Six Major Puzzles in International Macroeconomics: Is there a Common Cause?" NBER Macroeconomics Annual 2000, 339–389.

[33] Ostry, J., A. Ghosh 2013. "Obstacles to International Policy Coordination, and How to Overcome Them". In Obstacles to International Policy Coordination, and How to Overcome Them. USA: International Monetary Fund.

[34] Ravn, M.O., and Mazzenga, E., 2004. "International Business Cycles: The Quantitative Role of Transportation Costs," Journal of International Money and Finance, 23, 645–671.

[35] Schmitt-Grohe,S. 1998 "The International Transmission of Economic Fluctuations:Effects of US Business Cycles on the Canadian Economy" Journal of International Economics 44, 257–87.

[36] Smets, F., Wouters, R., 2007. "Shocks and Frictions in US Business Cycles: A Bayesian DSGE Approach," American Economic Review, 97, 586-606.

[37] Stockman, A., Tesar, L., 1995. "Tastes and technology in a two-country model of the business cycle: explaining international comovements," American Economic Review 85, 168–85.

[38] Truman, Edwin M. 2004. "A Critical Review of Coordination Efforts in the Past. In Macroeconomic Policies in the World Economy", ed. Horst Siebert. Heidelberg: Springer.

[39] Truman, Edwin M. 2019. "International Coordination of Economic Policies in the Global Financial Crisis: Successes, Failures, and Consequences," Working Paper, Peterson Institute for International Economics, 19-11.

[40] Zimmermann, C., 1997. "International Real Business Cycles Among Heterogeneous Countries," European Economic Review, 41, 319–55.

Table 1. Historical decompositions: Domestic, foreign, common shocks

	Domestic shocks	Foreign shocks	Common shocks		Domestic shocks	Foreign shocks	Common shocks
Canada				**Japan**			
output	0.66	0.22	0.12	output	0.44	0.29	0.27
consumption	0.73	0.14	0.13	consumption	0.54	0.26	0.20
investment	0.78	0.12	0.10	investment	0.37	0.29	0.34
labor	0.55	0.31	0.14	labor	0.40	0.27	0.33
wage inflation	0.83	0.04	0.13	wage inflation	0.57	0.24	0.19
net worth	0.91	0.05	0.04	net worth	0.89	0.07	0.04
interest rates	0.69	0.15	0.15	interest rates	0.22	0.50	0.28
inflation, imports	0.45	0.38	0.17	inflation, imports	0.41	0.37	0.22
inflation, domestic	0.87	0.05	0.08	inflation, domestic	0.51	0.27	0.22
average	**0.72**	**0.16**	**0.12**		**0.48**	**0.28**	**0.23**
France				**United Kingdom**			
output	0.49	0.18	0.33	output	0.55	0.18	0.27
consumption	0.73	0.12	0.15	consumption	0.70	0.08	0.22
investment	0.34	0.18	0.48	investment	0.63	0.08	0.29
labor	0.46	0.22	0.32	labor	0.95	0.02	0.03
wage inflation	0.41	0.22	0.36	wage inflation	0.79	0.04	0.17
net worth	0.73	0.05	0.23	net worth	0.84	0.04	0.12
interest rates	0.46	0.20	0.34	interest rates	0.42	0.13	0.46
inflation, imports	0.30	0.45	0.25	inflation, imports	0.48	0.25	0.27
inflation, domestic	0.33	0.25	0.43	inflation, domestic	0.62	0.03	0.34
average	**0.47**	**0.21**	**0.32**		**0.67**	**0.09**	**0.24**
Germany				**United States**			
output	0.67	0.21	0.12	output	0.58	0.12	0.31
consumption	0.81	0.10	0.09	consumption	0.73	0.04	0.23
investment	0.64	0.25	0.12	investment	0.60	0.06	0.34
labor	0.47	0.32	0.20	labor	0.48	0.10	0.42
wage inflation	0.52	0.18	0.31	wage inflation	0.53	0.10	0.37
net worth	0.78	0.04	0.18	net worth	0.83	0.02	0.15
interest rates	0.47	0.23	0.29	interest rates	0.55	0.06	0.39
inflation, imports	0.31	0.37	0.31	inflation, imports	0.57	0.12	0.31
inflation, domestic	0.47	0.24	0.29	inflation, domestic	0.44	0.09	0.47
average	**0.57**	**0.22**	**0.21**		**0.59**	**0.08**	**0.33**
Italy							
output	0.64	0.20	0.17				
consumption	0.72	0.14	0.15				
investment	0.55	0.20	0.26				
labor	0.52	0.28	0.20				
wage inflation	0.60	0.11	0.29				
net worth	0.78	0.04	0.18				
interest rates	0.60	0.24	0.16				
inflation, imports	0.42	0.40	0.18				
inflation, domestic	0.53	0.18	0.29				
average	**0.59**	**0.20**	**0.21**				

Note: The statistics are obtained from estimations that use data from the corresponding country and the rest of G-7. These statistics represent the average contributions of common, foreign and domestic shocks to the historical variance of the macroeconomic variables listed in columns 1 and 5. The averages are computed across time and the contributions are aggregated by type of shock (domestic, foreign and common).

Table 2. Historical decompositions: Demand, financial, price and productivity shocks

	Demand shocks	Financial shocks	Price and Productivity Shocks		Demand shocks	Financial shocks	Price and Productivity Shocks
Canada				**Japan**			
output	0.43	0.37	0.20	output	0.37	0.39	0.24
consumption	0.55	0.35	0.10	consumption	0.46	0.40	0.13
investment	0.36	0.53	0.10	investment	0.23	0.59	0.17
labor	0.33	0.30	0.37	labor	0.25	0.26	0.49
wage inflation	0.14	0.24	0.62	wage inflation	0.17	0.42	0.42
net worth	0.09	0.80	0.11	net worth	0.05	0.83	0.12
interest rates	0.21	0.48	0.32	interest rates	0.22	0.46	0.32
inflation, imports	0.15	0.44	0.41	inflation, imports	0.06	0.39	0.55
inflation, domestic	0.17	0.29	0.54	inflation, domestic	0.11	0.41	0.48
average	**0.27**	**0.42**	**0.31**	**average**	**0.21**	**0.46**	**0.32**
France				**United Kingdom**			
output	0.41	0.43	0.16	output	0.39	0.45	0.16
consumption	0.60	0.33	0.07	consumption	0.51	0.32	0.16
investment	0.32	0.59	0.08	investment	0.36	0.49	0.15
labor	0.31	0.35	0.34	labor	0.06	0.07	0.87
wage inflation	0.27	0.44	0.29	wage inflation	0.05	0.10	0.85
net worth	0.07	0.85	0.07	net worth	0.07	0.64	0.29
interest rates	0.26	0.53	0.21	interest rates	0.18	0.49	0.32
inflation, imports	0.14	0.53	0.33	inflation, imports	0.10	0.32	0.58
inflation, domestic	0.24	0.46	0.30	inflation, domestic	0.05	0.10	0.85
average	**0.29**	**0.50**	**0.21**	**average**	**0.20**	**0.33**	**0.47**
Germany				**United States**			
output	0.46	0.39	0.15	output	0.47	0.35	0.18
consumption	0.70	0.26	0.05	consumption	0.60	0.30	0.11
investment	0.26	0.64	0.10	investment	0.46	0.41	0.12
labor	0.33	0.29	0.38	labor	0.38	0.31	0.32
wage inflation	0.14	0.44	0.42	wage inflation	0.22	0.32	0.46
net worth	0.05	0.89	0.06	net worth	0.11	0.74	0.15
interest rates	0.28	0.49	0.23	interest rates	0.25	0.48	0.27
inflation, imports	0.12	0.47	0.41	inflation, imports	0.12	0.30	0.58
inflation, domestic	0.11	0.52	0.36	inflation, domestic	0.21	0.31	0.48
average	**0.27**	**0.49**	**0.24**	**average**	**0.31**	**0.39**	**0.30**
Italy							
output	0.37	0.47	0.16				
consumption	0.56	0.35	0.09				
investment	0.28	0.64	0.08				
labor	0.28	0.38	0.34				
wage inflation	0.18	0.40	0.42				
net worth	0.06	0.82	0.11				
interest rates	0.24	0.51	0.25				
inflation, imports	0.10	0.48	0.42				
inflation, domestic	0.17	0.45	0.38				
average	**0.25**	**0.50**	**0.25**				

Note: The statistics are obtained from estimations that use data from the corresponding country and the rest of G-7. These statistics represent the average contributions of demand, financial, and price and productivity shocks to the historical variance of the macroeconomic variables listed in columns 1 and 5. The averages are computed across time and the contributions are aggregated by type of shock (demand, financial, and price and productivity).

Table 3. Forecast error variance decompositions: Domestic, foreign, common shocks

	Domestic shocks	Foreign shocks	Common shocks		Domestic shocks	Foreign shocks	Common shocks
Canada				**Japan**			
output	0.60	0.24	0.16	output	0.52	0.17	0.31
consumption	0.61	0.28	0.12	consumption	0.72	0.15	0.14
investment	0.82	0.04	0.14	investment	0.28	0.18	0.55
labor	0.65	0.23	0.13	labor	0.65	0.06	0.29
wage inflation	0.70	0.27	0.03	wage inflation	0.61	0.20	0.19
net worth	0.76	0.23	0.01	net worth	0.84	0.15	0.00
interest rates	0.65	0.24	0.11	interest rates	0.44	0.29	0.27
inflation, imports	0.60	0.18	0.22	inflation, imports	0.71	0.13	0.16
inflation, domestic	0.68	0.25	0.08	inflation, domestic	0.47	0.32	0.20
average	**0.67**	**0.22**	**0.11**		**0.58**	**0.18**	**0.23**
France				**United Kingdom**			
output	0.53	0.17	0.29	output	0.78	0.08	0.14
consumption	0.82	0.09	0.09	consumption	0.90	0.06	0.04
investment	0.35	0.18	0.46	investment	0.79	0.05	0.16
labor	0.76	0.12	0.12	labor	1.00	0.00	0.00
wage inflation	0.67	0.26	0.08	wage inflation	0.83	0.15	0.02
net worth	0.83	0.05	0.11	net worth	0.77	0.22	0.01
interest rates	0.49	0.21	0.31	interest rates	0.62	0.09	0.29
inflation, imports	0.27	0.24	0.49	inflation, imports	0.45	0.16	0.39
inflation, domestic	0.44	0.29	0.27	inflation, domestic	0.76	0.13	0.12
average	**0.57**	**0.18**	**0.25**		**0.77**	**0.10**	**0.13**
Germany				**United States**			
output	0.67	0.23	0.10	output	0.56	0.15	0.29
consumption	0.90	0.05	0.05	consumption	0.59	0.18	0.22
investment	0.49	0.39	0.12	investment	0.64	0.04	0.32
labor	0.84	0.08	0.07	labor	0.35	0.22	0.43
wage inflation	0.56	0.36	0.08	wage inflation	0.58	0.25	0.17
net worth	0.81	0.12	0.07	net worth	0.78	0.20	0.02
interest rates	0.49	0.29	0.23	interest rates	0.62	0.16	0.22
inflation, imports	0.38	0.13	0.48	inflation, imports	0.51	0.22	0.27
inflation, domestic	0.52	0.26	0.22	inflation, domestic	0.30	0.32	0.38
average	**0.63**	**0.21**	**0.16**		**0.55**	**0.19**	**0.26**
Italy							
output	0.67	0.14	0.18				
consumption	0.81	0.13	0.06				
investment	0.62	0.07	0.31				
labor	0.85	0.06	0.09				
wage inflation	0.55	0.40	0.05				
net worth	0.86	0.10	0.04				
interest rates	0.60	0.25	0.15				
inflation, imports	0.50	0.21	0.29				
inflation, domestic	0.68	0.21	0.11				
average	**0.68**	**0.18**	**0.14**				

Note: The statistics are obtained from estimations that use data from the corresponding country and the rest of G-7. These statistics represent the average contributions of common, foreign and domestic shocks to the forecast error variance of the macroeconomic variables listed in columns 1 and 5. The averages are computed across time and the contributions are aggregated by type of shock (domestic, foreign and common). The forecast horizon is 1 quarter ahead.

Table 4. Forecast error variance decompositions: Demand, financial, price and productivity shocks

	Demand shocks	Financial shocks	Price and productivty shocks		Demand shocks	Financial shocks	Price and productivty shocks
Canada				**Japan**			
output	0.75	0.16	0.08	output	0.66	0.16	0.10
consumption	0.88	0.10	0.02	consumption	0.81	0.16	0.02
investment	0.70	0.27	0.03	investment	0.35	0.53	0.09
labor	0.44	0.09	0.46	labor	0.15	0.03	0.79
wage inflation	0.01	0.03	0.96	wage inflation	0.14	0.33	0.52
net worth	0.00	0.96	0.04	net worth	0.00	0.99	0.00
interest rates	0.13	0.48	0.38	interest rates	0.15	0.47	0.34
inflation, imports	0.03	0.09	0.82	inflation, imports	0.00	0.09	0.87
inflation, domestic	0.00	0.05	0.94	inflation, domestic	0.04	0.25	0.71
average	**0.33**	**0.25**	**0.42**	**average**	**0.26**	**0.33**	**0.38**
France				**United Kingdom**			
output	0.73	0.15	0.06	output	0.78	0.13	0.06
consumption	0.96	0.04	0.00	consumption	0.96	0.03	0.01
investment	0.67	0.31	0.01	investment	0.62	0.25	0.13
labor	0.20	0.04	0.74	labor	0.00	0.00	1.00
wage inflation	0.22	0.12	0.66	wage inflation	0.01	0.00	0.98
net worth	0.01	0.99	0.01	net worth	0.01	0.95	0.04
interest rates	0.18	0.63	0.17	interest rates	0.15	0.50	0.34
inflation, imports	0.03	0.24	0.59	inflation, imports	0.02	0.02	0.91
inflation, domestic	0.15	0.17	0.67	inflation, domestic	0.00	0.01	0.99
average	**0.35**	**0.30**	**0.32**	**average**	**0.28**	**0.21**	**0.50**
Germany				**United States**			
output	0.79	0.14	0.05	output	0.74	0.17	0.07
consumption	0.96	0.03	0.00	consumption	0.96	0.03	0.00
investment	0.67	0.30	0.02	investment	0.77	0.20	0.02
labor	0.25	0.04	0.69	labor	0.41	0.09	0.48
wage inflation	0.04	0.11	0.85	wage inflation	0.06	0.12	0.82
net worth	0.00	0.99	0.01	net worth	0.01	0.97	0.02
interest rates	0.19	0.59	0.20	interest rates	0.16	0.58	0.25
inflation, imports	0.02	0.08	0.85	inflation, imports	0.01	0.03	0.95
inflation, domestic	0.04	0.15	0.81	inflation, domestic	0.05	0.10	0.84
average	**0.33**	**0.27**	**0.39**	**average**	**0.35**	**0.25**	**0.39**
Italy							
output	0.61	0.18	0.19				
consumption	0.92	0.05	0.03				
investment	0.56	0.37	0.07				
labor	0.23	0.06	0.69				
wage inflation	0.04	0.02	0.94				
net worth	0.00	0.96	0.03				
interest rates	0.12	0.42	0.45				
inflation, imports	0.01	0.07	0.89				
inflation, domestic	0.03	0.03	0.94				
average	**0.28**	**0.24**	**0.47**				

Note: The statistics are obtained from estimations that use data from the corresponding country and the rest of G-7. These statistics represent the average contributions of demand, financial, and price and productivity shocks to the forecast error variance of the macroeconomic variables listed in columns 1 and 5. The averages are computed across time and the contributions are aggregated by type of shock (demand, financial, and price and productivity). The forecast horizon is 1 quarter ahead.

Table 5. Forecast error variance decompositions: Longer forecast horizon

	Domestic shocks	Foreign shocks	Common shocks		Domestic shocks	Foreign shocks	Common shocks
Canada				**Japan**			
output	0.60	0.24	0.16	output	0.51	0.17	0.32
consumption	0.61	0.28	0.11	consumption	0.69	0.16	0.15
investment	0.80	0.08	0.12	investment	0.41	0.19	0.41
labor	0.65	0.23	0.13	labor	0.64	0.07	0.29
wage inflation	0.71	0.27	0.01	wage inflation	0.63	0.18	0.19
net worth	0.76	0.23	0.01	net worth	0.84	0.15	0.01
interest rates	0.65	0.24	0.11	interest rates	0.44	0.28	0.28
inflation, imports	0.60	0.20	0.20	inflation, imports	0.70	0.15	0.16
inflation, domestic	0.70	0.26	0.04	inflation, domestic	0.57	0.25	0.18
average	**0.68**	**0.22**	**0.10**	**average**	**0.60**	**0.18**	**0.22**
France				**United Kingdom**			
output	0.54	0.17	0.29	output	0.76	0.09	0.15
consumption	0.82	0.10	0.08	consumption	0.89	0.06	0.05
investment	0.43	0.17	0.40	investment	0.78	0.07	0.15
labor	0.76	0.12	0.12	labor	1.00	0.00	0.00
wage inflation	0.68	0.25	0.07	wage inflation	0.81	0.17	0.01
net worth	0.83	0.06	0.12	net worth	0.77	0.21	0.02
interest rates	0.48	0.22	0.30	interest rates	0.62	0.09	0.29
inflation, imports	0.28	0.28	0.44	inflation, imports	0.48	0.16	0.36
inflation, domestic	0.57	0.25	0.18	inflation, domestic	0.79	0.12	0.09
average	**0.60**	**0.18**	**0.22**	**average**	**0.77**	**0.11**	**0.12**
Germany				**United States**			
output	0.65	0.23	0.12	output	0.56	0.16	0.28
consumption	0.89	0.06	0.05	consumption	0.61	0.19	0.20
investment	0.52	0.36	0.12	investment	0.65	0.07	0.28
labor	0.83	0.09	0.08	labor	0.37	0.21	0.41
wage inflation	0.58	0.37	0.04	wage inflation	0.62	0.25	0.13
net worth	0.80	0.12	0.08	net worth	0.77	0.21	0.02
interest rates	0.48	0.31	0.21	interest rates	0.59	0.18	0.23
inflation, imports	0.41	0.17	0.42	inflation, imports	0.49	0.22	0.29
inflation, domestic	0.59	0.33	0.08	inflation, domestic	0.43	0.28	0.30
average	**0.64**	**0.23**	**0.13**	**average**	**0.56**	**0.20**	**0.24**
Italy							
output	0.66	0.18	0.16				
consumption	0.80	0.15	0.05				
investment	0.66	0.11	0.23				
labor	0.83	0.08	0.09				
wage inflation	0.56	0.42	0.02				
net worth	0.84	0.11	0.05				
interest rates	0.59	0.27	0.14				
inflation, imports	0.52	0.26	0.22				
inflation, domestic	0.60	0.36	0.04				
average	**0.67**	**0.22**	**0.11**				

Note: The statistics are obtained from estimations that use data from the corresponding country and the rest of G-7. These statistics represent the average contributions of common, foreign and domestic shocks to the forecast error variance of the macroeconomic variables listed in columns 1 and 5. Averages are computed across time and contributions are aggregated by type of shock (domestic, foreign and common). The forecast horizon is 10 quarters ahead.

Table 6. Assessment of economic integration

Economic integration

	Canada	France	Germany	Italy	Japan	UK	US
(Imports+Exports) / GDP	0.56	0.44	0.63	0.43	0.24	0.37	0.20
(Foreign Assets + Liabilities) / GDP	2.97	4.85	3.83	2.52	1.89	9.12	2.50
Correlation with G-7							
output	0.72	0.76	0.68	0.74	0.70	0.73	0.28
inflation	0.55	0.41	-0.15	0.12	-0.30	0.35	-0.30
net worth	0.86	0.90	0.91	0.85	0.64	0.94	0.89
Historical decompositions							
Foreign + common	0.28	0.53	0.43	0.41	0.52	0.33	0.42
Foreign	0.16	0.21	0.22	0.20	0.28	0.09	0.08
Common	0.12	0.32	0.21	0.21	0.23	0.24	0.33
Foreign+ common, 1997-2007	0.33	0.51	0.44	0.43	0.57	0.39	0.43
Foreign+ common, 2010-2019	0.23	0.53	0.44	0.38	0.46	0.32	0.39
Forecast Error Variance Decompositions							
Foreign + common	0.33	0.43	0.37	0.32	0.42	0.23	0.45
Foreign	0.22	0.18	0.21	0.18	0.18	0.10	0.19
Common	0.11	0.25	0.16	0.14	0.23	0.13	0.26

Rankings

	Trade Openness	Financial Openness	HD	FEVD
Canada	2	4	7	5
France	3	2	1	2
Germany	1	3	3	4
Italy	4	5	5	6
Japan	6	7	2	3
UK	5	1	6	7
US	7	6	4	1

Correlation coefficients

	Trade Openness	Financial Openness	HD	FEVD
Trade Openness	1.00			
Financial Openness	0.11	1.00		
HD	-0.34	-0.31	1.00	
FEVD	-0.36	-0.66	0.71	1.00

Note: The statistics in the first five rows of the table are computed with the data used in my estimations. The historical and forecast error variance decomposition statistics (HD and FEVD) represent the average contributions of shocks across the time period and the different macroeconomic variables. In the rankings panel, lower numbers indicate higher integration. In calculating these ranking and the correlation coefficients in the bottom panel, I use the share of foreign and common shocks in FEVD and HD.

Table 7. Drivers of macroeconomic volatility in the G-7

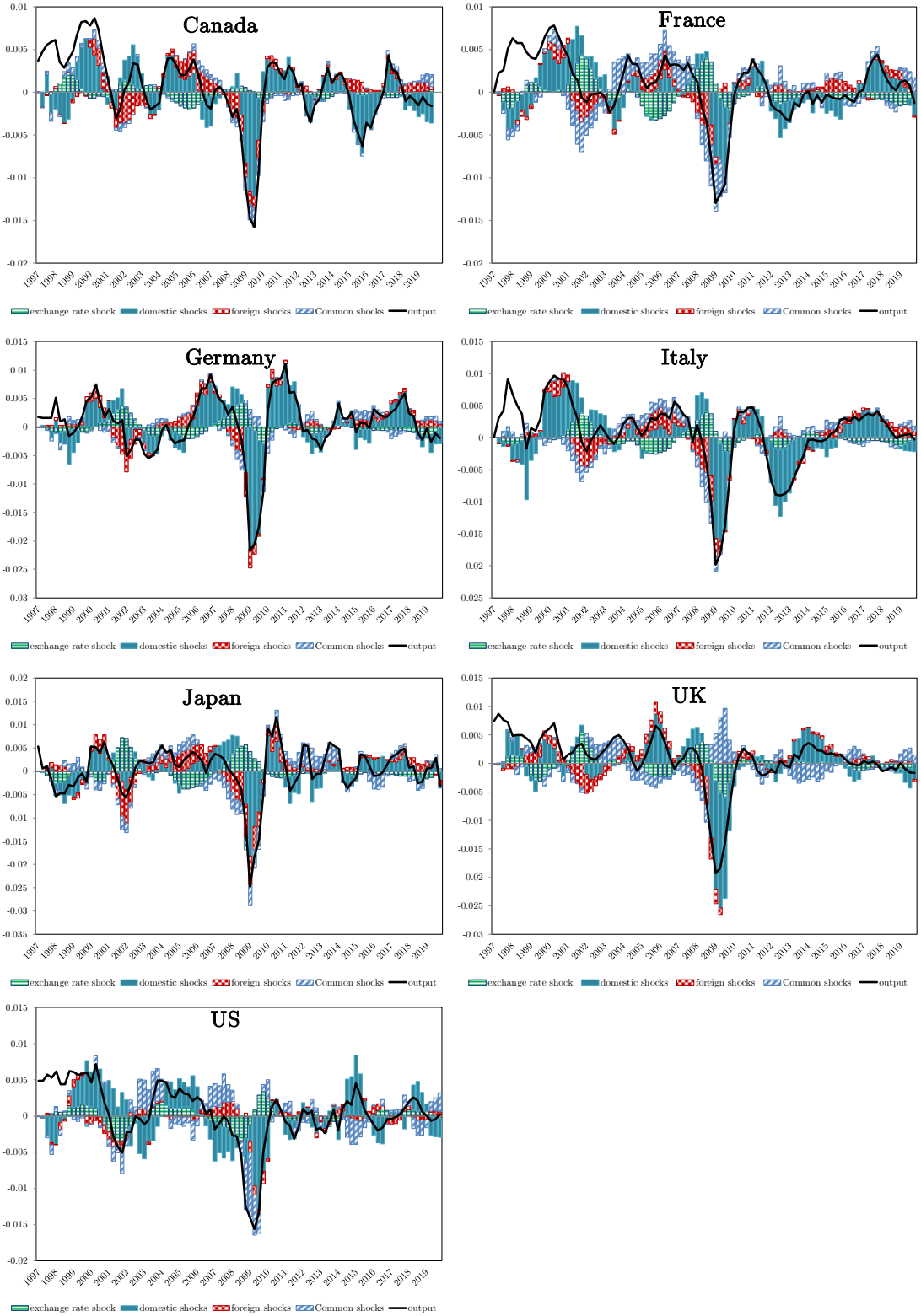
	Historical Decompositions		FEVD	
	G-7 specific shocks	Other shocks	G-7 specific shocks	Other shocks
G-7 w/o Canada	0.5782	0.4218	0.4044	0.5956
G-7 w/o France	0.4789	0.5211	0.3623	0.6377
G-7 w/o Germany	0.5058	0.4942	0.3585	0.6415
G-7 w/o Italy	0.4840	0.5160	0.4164	0.5836
G-7 w/o Japan	0.5590	0.4410	0.4264	0.5736
G-7 w/o United Kingdom	0.4600	0.5400	0.3296	0.6704
G-7 w/o United States	0.4410	0.5590	0.3304	0.6696

Note: The statistics are obtained from estimations that use data from the corresponding country and the rest of G-7. The numbers in the third and fifth columns represent the contributions of common and foreign shocks to the macroeconomic variation in the rest of the G-7 where the foreign economy is the one that is excluded from G-7.

Figure 1. Historical decomposition of output: Domestic, foreign, common shocks

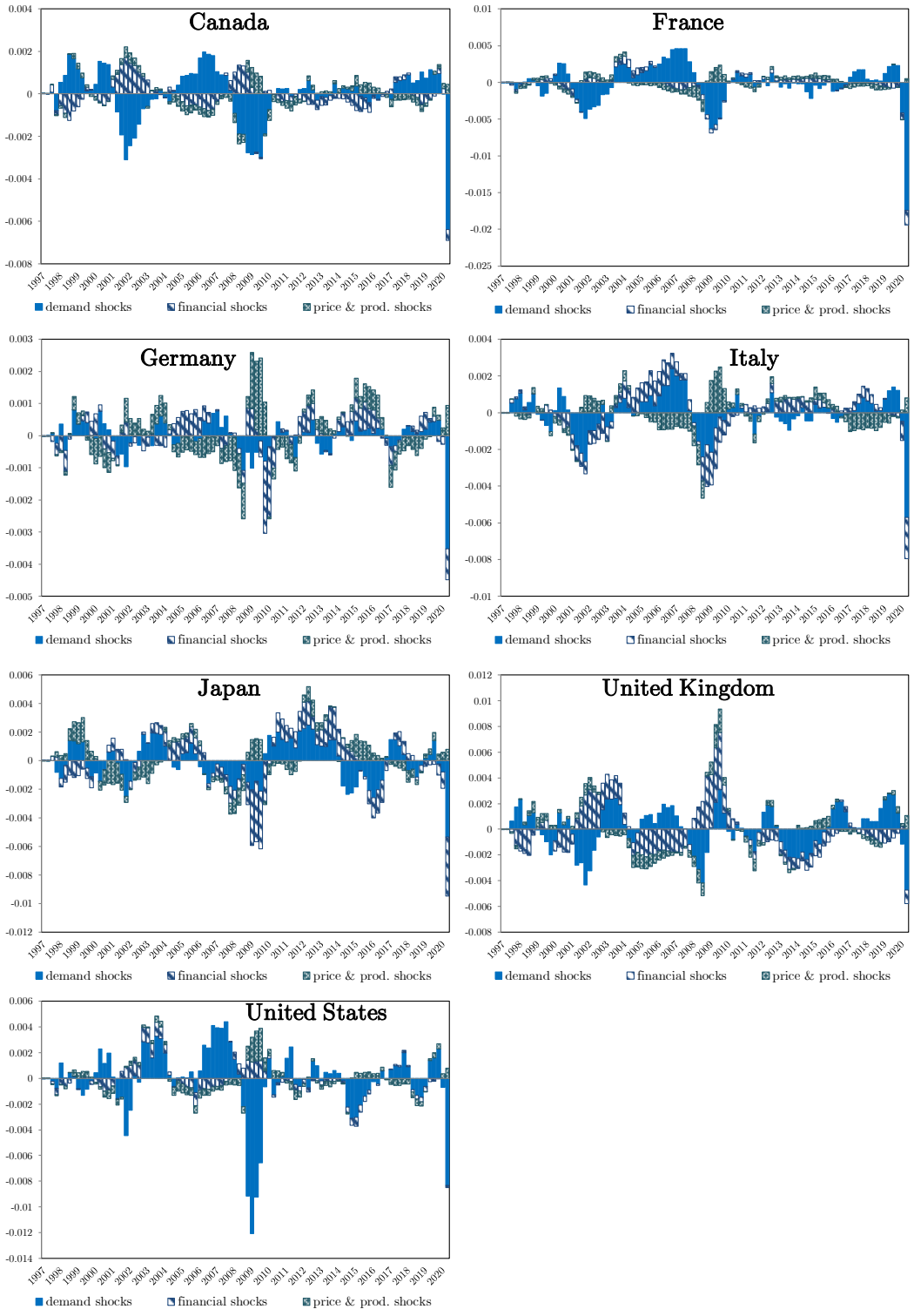
Note: The statistics are obtained from estimations that use data from the corresponding country and the rest of G-7. These figures depict the contributions of common, foreign and domestic shocks to the historical variance of the corresponding country's output. The contributions are aggregated by type of shock (domestic, foreign and common).

Figure 2. Historical decomposition of output excluding 2020



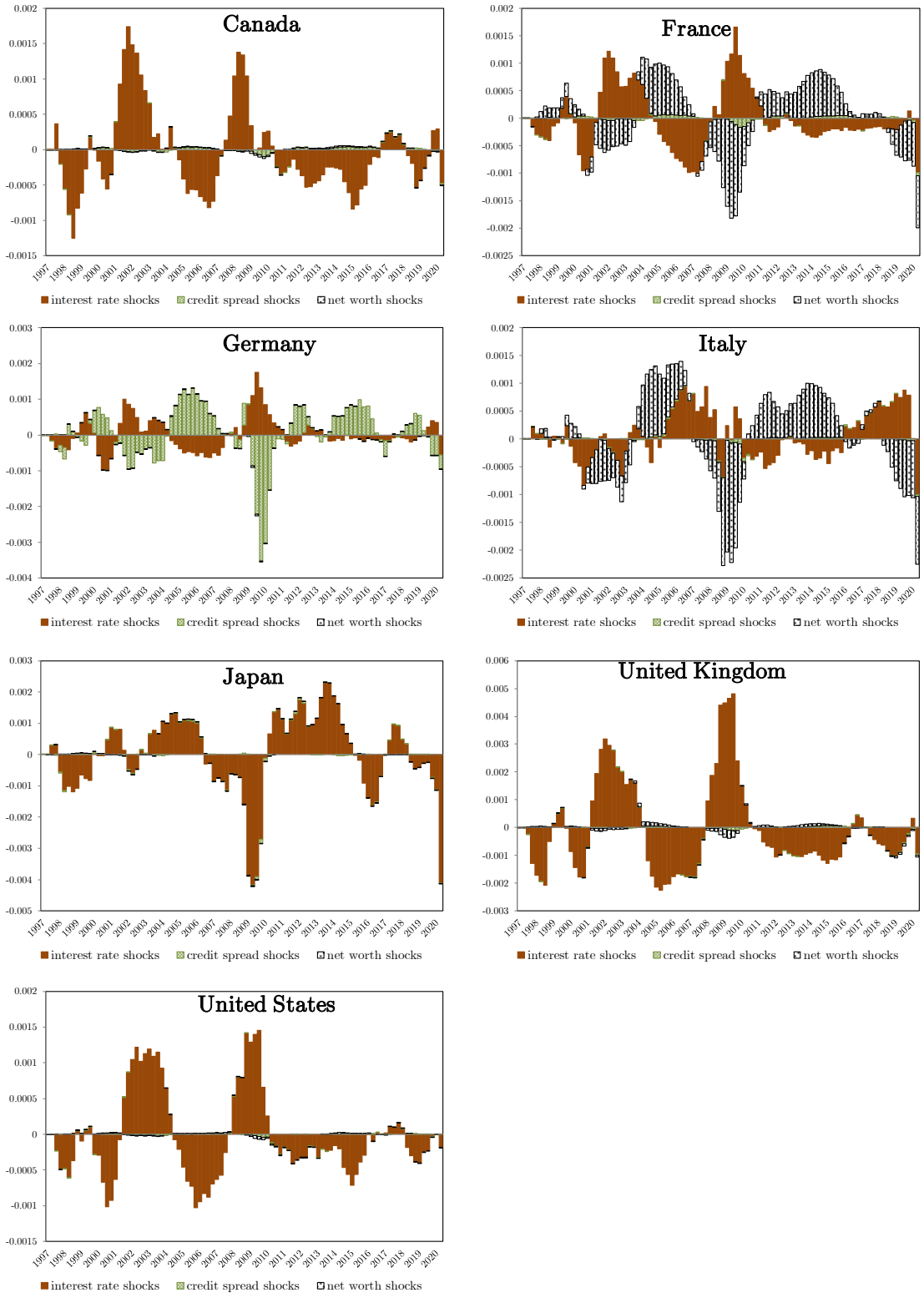
Note: The statistics are obtained from estimations that use data from the corresponding country and the rest of G-7. These figures depict the contributions of common, foreign and domestic shocks to the historical variance of the corresponding country's output. The contributions are aggregated by type of shock (domestic, foreign and common). The observations for 2020 are excluded from the graph.

Figure 3. Historical decompositions: Common demand, financial, price and prod. shocks



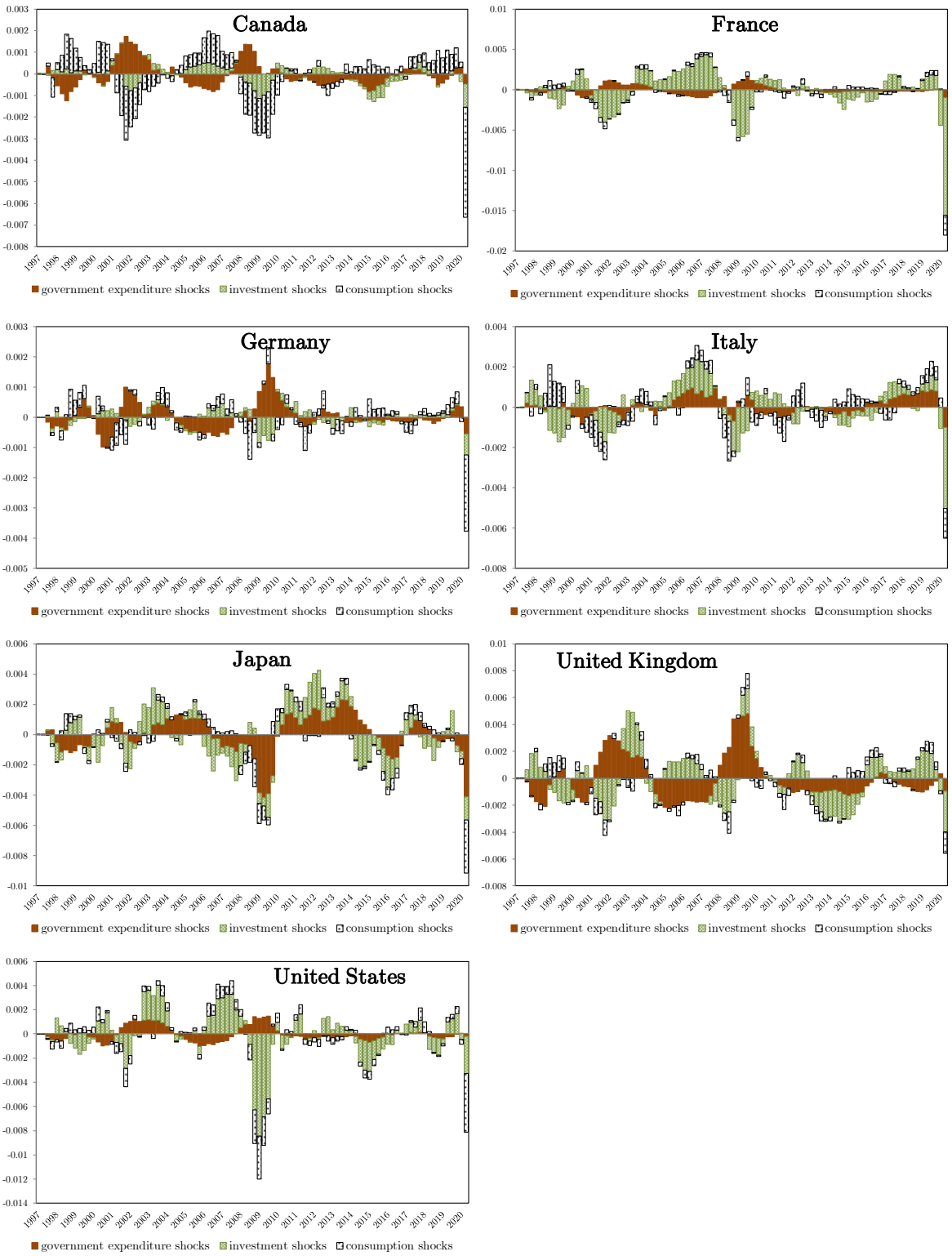
Note: The statistics are obtained from estimations that use data from the corresponding country and the rest of G-7. These figures depict the contributions of common demand, financial, and price and productivity shocks to the historical variance of the corresponding country's output. The contributions are aggregated by the type of shock (common demand, financial, and price and productivity shocks).

Figure 4. Historical decompositions: Common financial shocks by type



Note: The statistics are obtained from estimations that use data from the corresponding country and the rest of G-7. These figures depict the contributions of common interest rate, credit spread, and net worth shocks to the historical variance of the corresponding country's output. The contributions are aggregated by the type of shock.

Figure 5. Historical decompositions: Common demand shocks by type



Note: The statistics are obtained from estimations that use data from the corresponding country and the rest of G-7. These figures depict the contributions of common government spending, investment, and consumption shocks to the historical variance of the corresponding country's output. The contributions are aggregated by the type of shock.