American Economic Journal: Macroeconomics 2016, 8(4): 177–198
http://dx.doi.org/10.1257/mac.20140092

The Great Recession: A Self-Fulfilling Global Panic†

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While the 2008–2009 financial crisis originated in the United States, output, consumption, and investment declined by similar magnitudes around the globe. Given the partial integration of both goods and financial markets, what can account for the remarkable global business cycle synchronicity during this period? To address this question, we develop a two-country model allowing for self-fulfilling business cycle panics. We show that a business cycle panic will necessarily be synchronized across countries as long as there is a minimum level of economic integration. Several factors, including tight credit, made the global economy particularly vulnerable to a global panic in 2008. (*JEL* E12, E32, E44, E58, F44, G01)

The 2008–2009 Great Recession clearly had its origins in the United States, where a historic drop in house prices had a deep impact on financial institutions and markets. It is remarkable then, as illustrated in Figure 1, that the steep decline in output, consumption, investment, and corporate profits during the second half of 2008 and beginning of 2009 was about the same in the rest of the world as in the United States.[1] Figure 2 shows that the decline in expectations of future GDP growth, as well as the increase in uncertainty about future growth, was also of a similar magnitude in the rest of the world as in the United States.[2] This co-movement of business cycles and of expectations is surprising both in the context of existing theory and historical experience. Figure 3 shows that during the Great Depression the decline in output in the rest of the world was much smaller than in the United States. There is extensive evidence that output correlations in the 2008–2009 recession were unprecedented (e.g., see Imbs 2010, Perri and Quadrini 2013, or International Monetary

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† Go to http://dx.doi.org/10.1257/mac.20140092 to visit the article page for additional materials and author disclosure statement(s) or to comment in the online discussion forum.

[1] The numbers for corporate profits in the last panel of Figure 1 have been derived by aggregating profits from firms listed in the Thomson Reuter's Worldscope database. We selected continuing firms over the interval and windsorized the top and bottom tails at 1 percent. The resulting profit series are divided by the gross domestic product (GDP) deflator. Only G7 countries are included due to data limitations.

[2] The data for Figure 2 come from Consensus Economics, who survey about 250 "prominent financial and economic" forecasters. Each January, forecasters are asked to give probabilities for GDP growth rate intervals for the current year. We compute the average and the variance for each country, as explained in more detail in Appendix A. For the non-US data line, we use the average across the 17 other countries in the sample.

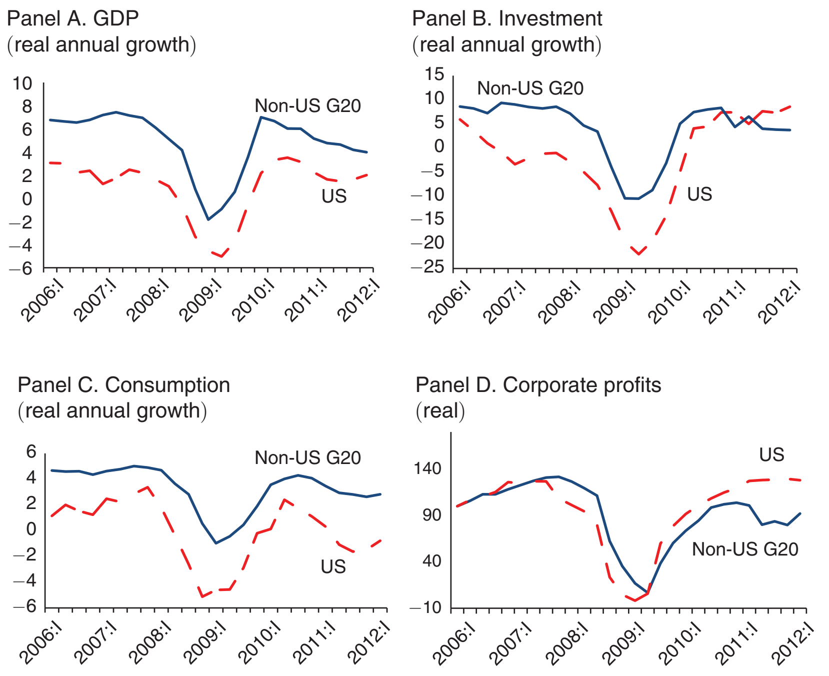

Figure 1. Synchronized Global Recession

Notes: Non-US G20 excludes Saudi Arabia for GDP and also China for consumption and investment. Corporate profits are net profits from Worldscope, aggregated over continuing firms within each country, divided by the GDP deflator and normalized at 100 in 2006:I. Non-US G7 is computed using relative PPP-adjusted GDP weights.

Source: GDP, investment, and consumption are from Datastream (growth over past four quarters).

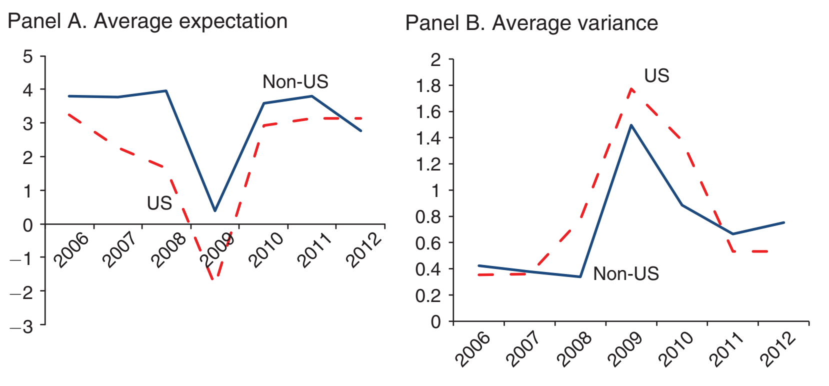

Figure 2. GDP Growth Forecasts Probabilities: Expectation and Variance

Notes: See Appendix A for a description. Non-United States: Australia, China, Hong Kong, India, Indonesia, Malaysia, New Zealand, Singapore, South Africa, Taiwan, Thailand, Japan, Germany, France, United Kingdom, Italy, Canada.

Source: Data are from Consensus Economics, based on one-year ahead forecast probabilities.

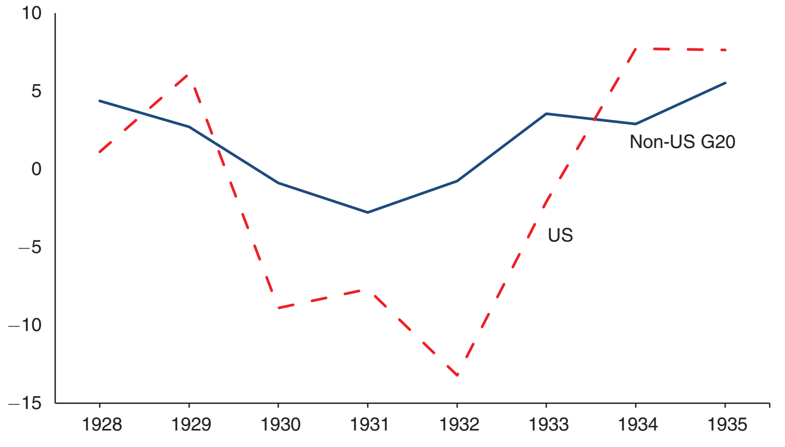

Figure 3. Real GDP Growth during the Great Depression

Notes: Broken line is the United States; solid line is the non-United States. G20 minus Saudi Arabia minus South Africa.

Source: Angus Maddison

Fund 2013), while there has been no indication of an increase in co-movements before the crisis.[3]

The strong co-movement also poses a theoretical challenge. Apart from exogenous global shocks, co-movement of business cycles in existing models is a result of a transmission of shocks across countries. Transmission can be either negative, such as in models with technology shocks, or positive, such as in models with financial shocks. But unless goods and financial markets are perfectly integrated, even positive transmission is partial at best.[4] The assumption of perfectly integrated markets is sharply contradicted by extensive evidence of large trade costs in goods markets, rejection of perfect financial integration (Backus-Smith puzzle) and strong home bias in both goods and financial markets. Moreover, recent empirical evidence suggests that the unprecedented synchronization of business cycles and asset prices during the Great Recession cannot be explained through standard trade and financial linkages.[5] International Monetary Fund (2013) suggests that the unusual co-movement is a result of an undetermined common shock, for example, in the form of a global panic.

This then leads to two questions that we aim to address in this paper. First, given the limited extent of goods and financial integration, how can we explain that the sharp decline in business cycles and expectations was similar in the rest of the world

[3] On the contrary, Hirata, Kose, and Otrok (2013) find that over the past 25 years the global component of business cycles has actually declined relative to local components (region and country-specific).

[4] van Wincoop (2013) considers a model matching the observed financial home bias and shows that the transmission of credit shocks across countries is limited. Credit shocks are perfectly transmitted across countries only when both goods and financial markets are perfectly integrated, as in Devereux and Sutherland (2011); Kollmann, Enders, and Müller (2011); and Perri and Quadrini (2013).

[5] See Rose and Spiegel (2010); Kamin and Pounder DeMarco (2012); Kalemli-Ozcan, Papaioannou, and Perri (2013); and International Monetary Fund (2013).

as in the United States during the Great Recession? Second, what can explain the difference relative to previous recessions?

We develop a two-country model that explains the recession as a demand collapse resulting from a self-fulfilling shock to expectations (or panic) as opposed to an exogenous shock to fundamentals. The view that the Great Recession could result from a self-fulfilling expectation shock has already gained significant traction in the literature in closed economy models.[6] When defining the Great Recession as the sharp decline in output over the three quarters from 2008:III to 2009:I, this view of an expectation shock or panic is quite natural. It is also consistent with evidence of a decline in expectations, shown in Figure 2, which was synchronized across countries.

The main contribution of the paper is to show that, in the presence of self-fulfilling expectation shocks, business cycles can be synchronized even under limited economic integration as long as integration passes a minimum threshold. This is the result of complementarity between domestic and foreign economies that generates an endogenous coordination of equilibria. If the foreign economy is strong, the domestic economy may not be vulnerable to a self-fulfilling bad equilibrium. Similarly, if the foreign economy is really weak, only a bad equilibrium may be feasible in the domestic country. Their interconnectedness makes it impossible for one country to have self-fulfilling favorable beliefs about the future while the other country has very negative beliefs. A self-fulfilling business cycle panic, if it happens, is necessarily global.

A couple of other papers have considered self-fulfilling shocks to business cycles and asset prices in open economy contexts. None of these highlights the endogenous coordination of beliefs under limited integration. Bacchetta and van Wincoop (2013) develop a two-country model with self-fulfilling risk-panics. But even when financial markets are perfectly integrated, such panics are generally not synchronized across countries. Perri and Quadrini (2013) consider a two-country model with self-fulfilling credit shocks. While output and consumption are perfectly synchronized across countries, this is the result of perfect financial and goods market integration and also arises with exogenous credit shocks. Martin and Rey (2006) develop a two-country model of a developed and emerging market. They focus on self-fulfilling shocks to the demand for goods and assets of the emerging market, which can arise under partial goods market and financial integration. But they do not consider global panics.

In general in models with multiple equilibria, two things are needed to shift to a bad equilibrium. The first is what is usually referred to as a "sunspot." The cause of this shift, or the nature of the sunspot, is never modeled. In the present context we like to think of US financial market turmoil in the fall of 2008 as a trigger event, but this is a matter of interpretation as opposed to modeling. More relevant is the second element. The economy needs to be at a point where it is vulnerable to self-fulfilling

[6] Examples include Farmer (2012b); Schmitt-Grohé and Uribe (2012); Aruoba, Cuba-Borda, and Schorfheide (2013); Mertens and Ravn (2014); and Heathcote and Perri (2015). Bacchetta, Tille, and van Wincoop (2012) focus on asset prices. Apart from models that relate specifically to the Great Recession, other recent contributions include Farmer (2012a); Liu and Wang (2014); and Benhabib, Wang, and Wen (2015). See Schmitt-Grohé (1997) for a review of the earlier models.

expectation shocks in the first place. Two features of the model play a role here. First, credit needs to be tight. Second, the world economy needs to be sufficiently integrated.

In order to see the role of tight credit, it is useful to understand the mechanism of the self-fulfilling beliefs. We adopt a New Keynesian framework, where firms set prices at the start of each period. Firm operations are constrained by internal funds as a result of borrowing constraints. When profits are very low and credit is tight, firms may not be able to invest enough to keep their productivity level. These assumptions can generate the following self-fulfilling circularity. If consumers expect lower future income, they will decrease their consumption. As a result of nominal rigidities, this drop in demand reduces output and current profits. If this decline in profits is strong enough, and firms face binding borrowing constraints, there will be a drop in investment that lowers future productivity. This reduces future income, so that expectations are self-fulfilling.[7]

Both the tight credit itself, and the mechanism of the model through which tight credit operates, connect well to the Great Recession, defined as the three quarters of very negative growth from 2008:III to 2009:I. First, credit was tight well before the sharp decline in output in the fall of 2008. This was the result of the large drop in the value of real estate and other fixed capital that started in the summer of 2006, which lead to balance sheet losses in the financial sector and reduced the value of collateral. From our perspective, this is not a shock to the model but simply a background condition that was in place prior to the Great Recession. Second, the mechanism is consistent with the sharp decline in profits seen in the data of similar magnitude in the United States and the rest of the world (Figure 1). Third, the demand shock in the model is consistent with micro evidence that firms were more affected by a sudden sharp drop in demand than sudden reduced access to credit (e.g., Kahle and Stulz 2013, Nguyen and Qiuan 2014). Notice that it is important to distinguish between tight credit, which leads to vulnerability in the model, and a credit shock (which the model does not have).

Apart from tight credit, another key vulnerability parameter in the model is the extent of integration. As we have argued, only when the economies are sufficiently integrated are they subject to coordinated panics. The increase in global integration in the decades prior to the Great Recession plays an important role here.

In Section I we present a benchmark two-country, two-period model and show how self-fulfilling equilibria arise. Section II analyzes the equilibria and determines when business cycle panics are global. Our main result, stated in Proposition 2, is that partial integration is sufficient to guarantee that business cycles are perfectly synchronized during a panic. We also show that economies are more vulnerable to such a global recession at times when credit is tight, as was the case during this time period. Section III concludes.

[7] This relates to the classic Paradox of Thrift, where higher saving implies lower demand, which reduces output and may actually end up lowering saving. For recent contributions, see Christiano (2004), Eggertsson (2010), and Eggertsson and Krugman (2012).

I. Model

There are two countries, Home and Foreign, and two periods, 1 and 2. The basic two-period New Keynesian structure is similar to closed economy models found in the literature, starting with Krugman (1998).[8] Prices are preset, while wages are flexible. There is partial integration of goods markets through trade. Countries are in financial autarky, with financial assets (claims on firms, a bond, and money) only held domestically. Goods are only used for consumption, abstracting from investment. There are households, firms, and a central bank. There is no uncertainty about the future (period 2). The only potential shock in the model is a sunspot shock in period 1 that can generate self-fulfilling shifts in expectations. Since the two countries have a symmetric structure, we focus on the description of the Home country. Foreign country variables are denoted with an asterisk.

A. *Households*

Households make consumption and leisure decisions in both periods. Households in the Home country maximize

$$\ln c_1 + \lambda l_1 + \beta\left(\ln c_2 + \lambda l_2\right), \tag{1}$$

where l_t is the fraction of time devoted to leisure in period t and c_t is the period-t consumption index of Home and Foreign goods:

$$c_t = \left(\frac{c_{H,t}}{\psi}\right)^{\psi}\left(\frac{c_{F,t}}{1-\psi}\right)^{1-\psi}, \tag{2}$$

where

$$c_{i,t} = \left(\int_0^1 c_{i,t}(j)^{\frac{\mu-1}{\mu}}\,dj\right)^{\frac{\mu}{\mu-1}} \quad \text{for } i = H, F. \tag{3}$$

Here, $c_{H,t}$ is the consumption index of Home goods $c_{H,t}(j)$, and $c_{F,t}$ the consumption index of Foreign goods $c_{F,t}(j)$. The elasticity of substitution among goods of the same country is $\mu > 1$, while the elasticity of substitution between Home and Foreign goods is 1. There is a preference home bias towards domestic goods as we assume $\psi > 0.5$. The specification is symmetric for the Foreign country, with $c^*_{H,t}(j)$, $c^*_{F,t}(j)$ denoting the consumption of individual Home and Foreign goods consumption by Foreign households.

The parameter ψ captures the degree of goods market integration. A value of $\psi > 0.5$ implies a positive preference for domestic goods, which is well-known to be indistinguishable from introducing positive trade costs without a preference

[8] See Mankiw and Weinzierl (2011) or Fernández-Villaverde, Guerrón-Quintana, and Rubio-Ramírez (2014) for recent contributions. Aghion, Bacchetta, and Banerjee (2000) analyze a small open economy.

home bias.[9] The limit $\psi = 0.5$ implies perfect goods market integration. As we will see, $\psi = 0.5$ also implies that in equilibrium $c_t = c_t^*$, so that financial markets are effectively complete even though there is no asset trade.[10] This is a feature that results specifically from the Cobb-Douglas specification and is familiar from Cole and Obstfeld (1991). We can then think of $\psi = 0.5$ as perfect economic integration across the two countries.

Let $P_{H,t}(j)$ and $P_{F,t}(j)$ be the price of Home and Foreign good j in the Home and Foreign currency and S_t the nominal exchange rate in period t (Home currency per unit of Foreign currency). Price indices are defined in the standard way:

$$P_{i,t} = \left(\int_0^1 P_{i,t}(j)^{1-\mu}\, dj\right)^{\frac{1}{1-\mu}} \qquad \text{for } i = H, F$$

$$P_t = P_{H,t}^{\psi}[S_t P_{F,t}]^{1-\psi} \qquad P_t^* = (P_{H,t}/S_t)^{1-\psi} P_{F,t}^{\psi}$$

$P_{H,t}$ and $P_{F,t}$ are price indices of Home and Foreign goods that are denominated in Home and Foreign currencies, respectively. P_t is the overall price index, denominated in the Home currency and P_t^* is the Foreign price index.

In period 1, Home households earn labor income $W_1(1 - l_1)$, where W_1 is the nominal wage rate. They also earn a dividend Π_1 and receive a transfer of $\overline{M}_1$ in money balances from the central bank. They use these resources to consume, buy Home nominal bonds B with interest rate i, and hold money balances M_1:

$$(4) \qquad \int_0^1 P_{H,1}(j) c_{H,1}(j)\, dj + \int_0^1 S_1 P_{F,1}(j) c_{F,1}(j)\, dj + B + M_1 = W_1(1 - l_1) + \Pi_1 + \overline{M}_1.$$

In period 2, Home households earn labor income $W_2(1 - l_2)$, earn a dividend Π_2, receive $(1 + i)B$ from bond holdings, carry over M_1 in money balances from period 1, and receive an additional money transfer of $\overline{M}_2 - \overline{M}_1$ from the central bank. These resources are then used to consume and hold money balances M_2:[11]

$$(5) \qquad \int_0^1 P_{H,2}(j) c_{H,2}(j)\, dj + \int_0^1 S_2 P_{F,2}(j) c_{F,2}(j)\, dj + M_2 = W_2(1 - l_2) + \Pi_2 + (1 + i)B + M_1 + (\overline{M}_2 - \overline{M}_1).$$

We assume a cash-in-advance constraint, with the buyer's currency being used for payment:

$$(6) \qquad \int_0^1 P_{H,t}(j) c_{H,t}(j)\, dj + \int_0^1 S_t P_{F,t}(j) c_{F,t}(j)\, dj \leq M_t.$$

[9] See, for example, Anderson and van Wincoop (2003).

[10] Financial markets are complete when the ratio of marginal utilities of consumption across the two countries is equal to the real exchange rate, which is 1 when $\psi = 0.5$.

[11] As usual in finite-time models, there is an implicit assumption on the final use of money, e.g., agents need to return the money stock to the central bank.

The constraint will always bind in period 2. It will bind in period 1 when the nominal interest rate i is positive. When $i = 0$, the constraint will generally not bind in period 1.

Households choose consumption and leisure to maximize (1) subject to (4)–(6). The first-order conditions give

$$c_2 = \beta(1+i)\frac{P_1}{P_2}c_1 \tag{7}$$

$$c_{i,t}(j) = \left(\frac{P_{i,t}(j)}{P_{i,t}}\right)^{-\mu} c_{i,t} \qquad i = H, F \tag{8}$$

$$c_{H,t} = \psi \frac{P_t}{P_{H,t}} c_t \tag{9}$$

$$c_{F,t} = (1-\psi)\frac{P_t}{S_t P_{F,t}} c_t \tag{10}$$

$$\frac{W_t}{P_t} = \lambda c_t. \tag{11}$$

Equation (7) is a standard intertemporal consumption Euler equation. Equations (8)–(10) represent the optimal consumption allocation within and across countries, and (11) represents the consumption-leisure trade-off.

B. *Firms*

There is a continuum of firms of mass one. Output of Home firm j in period t is

$$y_t(j) = A_t L_t(j), \tag{12}$$

where $L_t(j)$ is labor input and A_t is labor productivity. Productivity in period one is normalized to $A_1 = 1$. We will refer to period 2 productivity simply as A, so $A_2 = A$. In period 2, firms can maintain the productivity level of 1 if in period 1 they pay a fixed cost z, which is real (in terms of the consumption index). In that case, $A = 1$. Otherwise, their period 2 productivity decreases to $A = A_L < 1$. The cost z represents an investment required to maintain the productivity of the firm.[12] The cost is paid to an agency, which operates at no cost and transfers its income to households. Therefore, the continuation cost z does not affect aggregate resources.

Firms cannot borrow and can only pay for the cost out of their profits. If first-period profits are insufficient to pay the cost z, second period productivity will be A_L. If first-period profits are sufficient to pay the cost z in period 1, firms only choose to

[12] This cost could also be modeled as a liquidity need as in Aghion et al. (2009).

pay z if the increased second-period profits more than offset the cost z. To be precise, firms maximize

$$\pi_1 - \iota z + \frac{1}{1+r}\pi_2. \tag{13}$$

Here $\iota = 1$ if the firm bears the cost z, and zero otherwise; $1 + r = (1 + i)P_1/P_2$ is the real interest rate; and π_t is the real value of period t profits, exclusive of the fixed cost z:

$$\pi_t = \frac{\Pi_t}{P_t} = \frac{P_{H,t}}{P_t}y_t - \frac{W_t}{P_t}L_t. \tag{14}$$

If $\pi_1 \geq z$, a firm will only bear the cost z if the increased present value of second-period profits is larger than z. This is the case for a particular firm j if

$$z < \frac{1}{1+r}\left[\pi_2(A(j) = 1) - \pi_2(A(j) = A_L)\right]. \tag{15}$$

In Appendix B we derive a condition, Assumption 1 below, which assures that (15) is always satisfied, independent of the level of productivity chosen by other firms in both countries and also independent of ψ. In that context, it is useful to define:

$$\overline{z} = \beta\frac{\theta - 1}{\theta}\frac{1}{\lambda\theta}A_L^{0.5}(1 - A_L^{\mu-1}).$$

ASSUMPTION 1:

$$z < \overline{z} \qquad \text{and} \qquad \mu > 2. \tag{16}$$

We will maintain this Assumption 1 throughout. Firms will then bear the cost z as long as first-period profits π_1 is at least z and will not bear the cost if π_1 is less than z.

From hereafter, we simply refer to π_1 as π. We then have

$$A \equiv A_2 = \begin{cases} 1 & \text{if} \quad \pi \geq z \\ A_L & \text{if} \quad \pi < z \end{cases}. \tag{17}$$

Firms set prices at the start of each period. Since prices in period 1 are preset, and their level does not matter for what follows, we simply assume that all Home firms set the same price of P_{H1}, so that $P_{H1}(j) = P_{H1}$. Similarly, for the Foreign firms $P_{F1}(j) = P_{F1}$. In period 2, Home firm j sets its price $P_{H,2}(j)$ to maximize profits. The optimal price is a markup over the marginal cost:

$$P_{H,2}(j) = \theta\frac{W_2}{A}, \tag{18}$$

where $\theta = \mu/(\mu - 1)$. Since all firms face the same wage, they set the same price.

The Keynesian assumption only bites for period 1 as no unexpected shocks happen after firms set prices at the start of period 2. As explained below, in period 1 there may be multiple equilibria, with lower consumption when a panic equilibrium occurs. Firms need to set prices at the start of period 1 before knowing consumption. Production will then adjust to demand. Lower consumption lowers goods demand and therefore production. Labor demand is then adjusted to satisfy the demand for goods.

C. *Central Banks*

The behavior of central banks is modeled as in other two-period models (e.g., Krugman 1998, or Mankiw and Weinzierl 2011). The central bank in each country follows the same policy, described by (M1) for the Home country.

M1: The central bank targets zero inflation and sets the period 1 interest rate at $(1/\beta) - 1$.

We assume that the central bank has a zero inflation target from period 1 to period 2, so that $P_2 = P_1$. Since the cash-in-advance constraint is binding in period 2, we have $\overline{M}_2 = P_2 c_2$, and the second-period price level can be controlled through the second-period money supply.

In the first period, the central bank sets the nominal interest rate i. We assume that the central bank sets the interest rate such that $(1 + i)\beta = 1$, as specified in (M1). As shown in Appendix C, this corresponds to the interest rate in the flexible price equilibrium of the model. The non-panic equilibrium of the model is then the same as the flexible price equilibrium. In a previous draft of this paper, Bacchetta and van Wincoop (2014), we also considered an alternative monetary policy, where during a panic the central bank lowers the interest rate to stimulate demand. While in general such a policy may help to avert self-fulfilling panics, this is not the case when the economy is already close to a structural zero lower bound (ZLB), where the natural real interest rate is close to zero (β close to 1).

D. *Market Clearing*

For the Home country the market clearing conditions are

$$y_t(j) = c_{H,t}(j) + c^*_{H,t}(j) \qquad t = 1,2 \tag{19}$$

$$\int_0^1 L_t(j)\, dj = 1 - l_t \qquad t = 1,2 \tag{20}$$

$$M_t = \overline{M}_t \qquad t = 1,2 \tag{21}$$

$$B = 0. \tag{22}$$

These represent respectively the goods markets, the labor market, the money market, and the bonds market clearing conditions. There is an analogous set of market clearing conditions for the Foreign country. This completes the description of the model.

E. *Equilibrium*

Prices, output, labor, and consumption are the same for all firms/goods within a country as they are modeled identically. Therefore $c_{H,t}(j) = c_{H,t}$, $c_{F,t}(j) = c_{F,t}$, $L_t(j) = L_t$, $y_t(j) = y_t$ and $P_{H,t}(j) = P_{H,t}$ and analogously for the Foreign country. Using this, an equilibrium of the model is defined as follows.

DEFINITION 1 (Definition of Equilibrium): *An equilibrium with policy rule* $(M1)$ *and initial conditions* $\{P_{H1}, P_{F1}, A_1\}$ *is given by profits* π, *productivity* A, *prices* $\{i, P_{H,2}, P_{F,2}, S_t, P_t, W_t\}$ *and allocations* $\{c_{Ht}, c_{Ft}, l_t, M_t, B, L_t, y_t\}$, $t = 1, 2$, *as well as their Foreign counterparts*, *such that*

(*i*) *budget constraints are satisfied*,

(*ii*) *consumption and leisure satisfy the first-order conditions and cash-in-advance constraints*,

(*iii*) *goods*, *labor*, *money*, *and bond markets clear*,

(*iv*) *output*, *first-period profits*, *and second-period prices satisfy respectively* (12), (14), *and* (18) *and their Foreign analogs, and*

(*v*) *second-period productivity satisfies* (17) *and its Foreign analog*.

We will first solve for equilibrium consumption, output, and first-period profits in both countries as a function of A and A^*. In the next section we will then consider which values of A and A^* establish an equilibrium.

Using that aggregate consumption can be written as $P_t c_t$, imposing equilibrium in labor, money, and bond markets (equations (20)–(22)), the budget constraints become

$$P_t c_t = W_t L_t + \Pi_t. \tag{23}$$

Since nominal profits are equal to $\Pi_t = P_{H,t} y_t - W_t L_t$, we have

$$P_t c_t = P_{H,t} y_t. \tag{24}$$

Next impose goods market equilibrium. Substituting (24), $c_{H,t} = \psi P_t c_t / P_{H,t}$ and $c^*_{H,t} = (1 - \psi) S_t P^*_t c^*_t / P_{H,t}$ into the goods market equilibrium condition (19), we have

$$P_t c_t = S_t P^*_t c^*_t. \tag{25}$$

Substituting the expressions for the price indices, this becomes

$$\frac{c_t}{c^*_t} = \left(\frac{P_{H,t}}{S_t P_{F,t}} \right)^{1-2\psi}. \tag{26}$$

Using that $P_t/P_{H,t} = (S_t P_{F,t}/P_{H,t})^{1-\psi}$, (26) implies

$$\frac{P_{H,t}}{P_t} = \left(\frac{c_t^*}{c_t}\right)^{\frac{1-\psi}{2\psi-1}}. \tag{27}$$

We can now derive equilibrium output and consumption as functions of A and A^*. First note that consumption is equal across both periods. Monetary policy implies $(1+i)P_1/P_2 = 1/\beta$, which together with the consumption Euler equation implies $c_1 = c_2$. The same is the case for the Foreign country. Equation (24), together with (27), then implies that output is also constant across the two periods: $y_1 = y_2$. We will refer to the constant consumption and output levels simply as c, c^*, y, and y^*.

Using (24) for period 2, we have

$$y = y_2 = \frac{P_2}{P_{H,2}} c_2 = \frac{P_2}{\theta W_2} A c_2 = \frac{A c_2}{\lambda \theta c_2} = \frac{A}{\lambda \theta}. \tag{28}$$

The third equality uses the optimal second period price from (18), while the fourth equality uses $W_2/P_2 = \lambda c_2$ from (11). Analogously, for the Foreign country we have $y = A^*/(\lambda\theta)$.

We can now solve for consumption in both countries as follows. (24) implies

$$c_t = \frac{P_{H,t}}{P_t} y_t = \left(\frac{c_t^*}{c_t}\right)^{\frac{1-\psi}{2\psi-1}} \frac{A}{\lambda\theta}. \tag{29}$$

The last equality uses (27) and the solution for output. The analogous equation for the Foreign country is

$$c_t^* = \left(\frac{c_t}{c_t^*}\right)^{\frac{1-\psi}{2\psi-1}} \frac{A^*}{\lambda\theta}. \tag{30}$$

Solving these last two equations gives

$$c = \frac{1}{\theta\lambda} A^{\psi} (A^*)^{1-\psi} \qquad c^* = \frac{1}{\theta\lambda} (A^*)^{\psi} A^{1-\psi}. \tag{31}$$

We can finally solve for first period profits, which in the Home country is equal to

$$\pi = \frac{P_{H,1}}{P_1} y_1 - \frac{W_1}{P_1} y_1. \tag{32}$$

This uses that first-period productivity is 1. From (24) we have $y_1 = (P_1/P_{H,1})c_1$. Substituting this into the profit expression above, together with $W_1/P_1 = \lambda c_1$ from (11), we have

$$\pi = c_1 - \lambda c_1^2 \frac{P_1}{P_{H,1}} = c_1 - \lambda c_1^2 \left(\frac{c_1}{c_1^*}\right)^{\frac{1-\psi}{2\psi-1}}. \tag{33}$$

The last equality uses (27). Substituting the consumption expressions (31) yields

$$\pi = \frac{A^{\psi}(A^*)^{1-\psi}}{\theta\lambda}\left(1 - \frac{A}{\theta}\right). \tag{34}$$

The analogous expression for the Foreign country is

$$\pi^* = \frac{(A^*)^{\psi}A^{1-\psi}}{\theta\lambda}\left(1 - \frac{A^*}{\theta}\right). \tag{35}$$

Second-period productivity in both countries, A and A^*, can take on the values 1 or A_L. This leaves a total of four potential equilibria. An equilibrium involves a combination of (A, A^*) such that

$$A = \begin{cases} 1 & \text{if} \quad \pi \geq z \\ A_L & \text{if} \quad \pi < z \end{cases} \qquad A^* = \begin{cases} 1 & \text{if} \quad \pi^* \geq z \\ A_L & \text{if} \quad \pi^* < z \end{cases}, \tag{36}$$

with profits a function of A and A^*, given by (34) and (35). We will now consider the existence of such equilibria in the next section.

II. Multiple Equilibria and Global Panics

There are four possible equilibria to consider: $(A, A^*) = (1,1)$, $(A, A^*) = (A_L, A_L)$, $(A, A^*) = (1, A_L)$, and $(A, A^*) = (A_L, 1)$. When there are multiple equilibria where productivity in a country can be both 1 or A_L, we refer to the latter as a *panic* equilibrium as it is simply generated by low expectations. Symmetric equilibria are those where productivity is the same in both countries. When this global productivity can be both 1 or A_L, we refer to the latter as a global panic. Asymmetric equilibria are those where there is a panic in one country, but not in the other.

A. *Symmetric Equilibria*

It is useful to start by considering the existence of symmetric equilibria, where $A = A^*$. We will make one additional assumption:[13]

ASSUMPTION 2:

$$\frac{A_L}{\theta\lambda}\left(1 - \frac{A_L}{\theta}\right) < z. \tag{37}$$

Assumptions 1 and 2 together guarantee the existence of both a symmetric panic and non-panic equilibrium. A corollary of Assumption 1 is that

$$\frac{1}{\theta\lambda}\left(1 - \frac{1}{\theta}\right) > z.$$

[13] It is easy to verify that Assumptions 1 and 2 can hold simultaneously for low enough values of A_L.

This implies that without a panic, first-period profits are large enough to cover the investment cost z, so that indeed productivity will be 1 in period 2. Assumption 2 implies that under a global panic profits are insufficient to cover the investment cost z, so that indeed productivity will be A_L in period 2. The following proposition is then immediate:

PROPOSITION 1: *If Assumptions 1 and 2 are satisfied, there are two symmetric equilibria, characterized by* $(A, A^*) = (1, 1)$ *and* $(A, A^*) = (A_L, A_L)$.

In these symmetric equilibria, consumption and output in both countries are $1/(\theta\lambda)$ in the non-panic equilibrium and $A_L/(\theta\lambda)$ in the panic equilibrium. A global panic therefore leads to a synchronized drop in consumption and output in both countries. A global panic also leads to a synchronized drop in profits. It drops from $(1/\theta\lambda)(1 - 1/\theta)$ (larger than z) to $(A_L/\theta\lambda)(1 - A_L/\theta)$ (less than z).

Multiple equilibria result from circularity in the model. When households expect low income in period 2, they reduce consumption in period 1. This reduces profits in period 1, which reduces investment and therefore productivity in period 2. The expected drop in period 2 income is then self-fulfilling.

B. *Asymmetric Equilibria*

We now consider the existence of asymmetric equilibria, maintaining Assumptions 1 and 2. Without loss of generality, consider a potential equilibrium where there is only a panic in the Home country: $(A, A^*) = (A_L, 1)$. From (34)–(35) it follows that in such an equilibrium Home and Foreign profits are

$$\pi = \frac{A_L^{\psi}}{\theta\lambda}\left(1 - \frac{A_L}{\theta}\right) \tag{38}$$

$$\pi^* = \frac{A_L^{1-\psi}}{\theta\lambda}\left(1 - \frac{1}{\theta}\right). \tag{39}$$

The asymmetric equilibrium exists when

$$\pi < z \leq \pi^*. \tag{40}$$

When $\pi < z$, the panic is an equilibrium in the Home country as its profits are less than z, so that it will not invest. When $\pi^* \geq z$, it is an equilibrium where the Foreign country does not panic as its profits are at least z, so that it will invest. Using the profit expressions (38)–(39) and condition (40), Appendix D proves the following proposition:

PROPOSITION 2: *If Assumptions 1 and 2 are satisfied, there is a threshold* $\psi(z) > 0.5$ *such that only the symmetric equilibria exist when* $\psi < \psi(z)$.

In order to understand Proposition 2, Figure 4 illustrates graphically under what conditions the asymmetric equilibrium $(A, A^*) = (A_L, 1)$ exists. It shows both π and

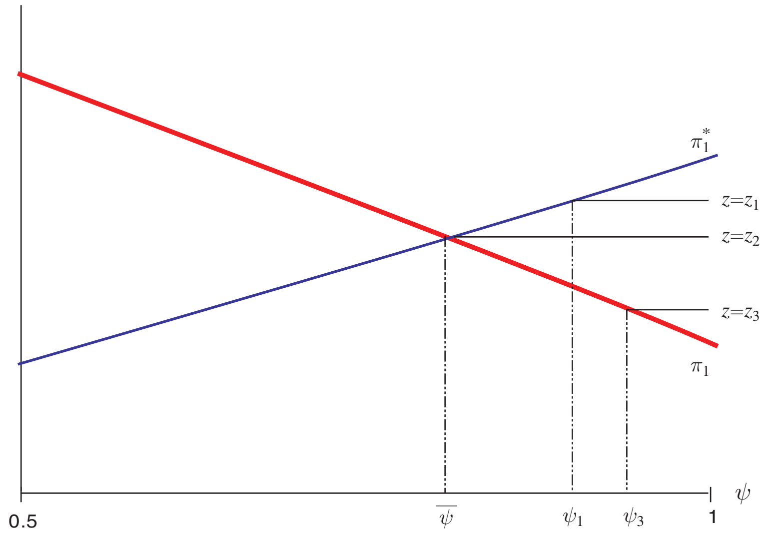

FIGURE 4. ON EXISTENCE OF ASYMMETRIC EQUILIBRIUM

Notes: The profit schedules are drawn under the assumption that there is a panic in Home and no panic in Foreign. When $z = z_i$, asymmetric equilibria only exist when $\psi > \psi_i$ for $i = 1$ and $i = 3$. When $z = z_2$, asymmetric equilibria exist as long as $\psi > \psi$.

π^*, given by respectively (38) and (39), as functions of ψ. The latter ranges from 0.5 (perfect integration) to 1 (autarky). Assumptions 1 and 2 imply that (40) is satisfied under autarky, as the conditions for an autarkic equilibrium are the same as for a symmetric global equilibrium. Under autarky, asymmetric equilibria therefore always exist. A country then may or may not panic, independent of the other country.

Two aspects of profits as a function of ψ are immediate from (38) and (39). First, Home profits depend negatively on ψ and Foreign profits depend positively on ψ. The more integrated countries become (the lower ψ), the more the Home country is positively impacted by the absence of a panic in Foreign, raising its profits. Similarly, more integration implies that the Foreign country is negatively impacted by the panic in Home, lowering its profits. Second, when $\psi = 0.5$, Home profits are actually larger than Foreign profits. In that case, consumption demand is equal in both countries, but the lower supply of Home goods improves its terms of trade, which leads to higher profits in Home.

It is clear from Figure 4 that the asymmetric equilibrium does not exist when $\psi < \overline{\psi}$, which is the level of ψ where the two profit schedules cross, as then Home profits are higher than Foreign profits. More generally (40) is not satisfied for ψ less than a cutoff $\psi(z)$ that lies somewhere between $\overline{\psi}$ and 1. This is illustrated in Figure 4. When $z = z_1$, the cutoff for ψ is ψ_1. When $\psi < \psi_1$, Foreign profits are below z, so that $(A, A^*) = (A_L, 1)$ cannot be an equilibrium. Similarly, when $z = z_3$, the cutoff for ψ is ψ_3. When $\psi < \psi_3$, Home profits are above z, so again $(A, A^*) = (A_L, 1)$ cannot be an equilibrium. The lowest possible cutoff value for ψ occurs when $z = z_2$, in which case the cutoff is $\psi = \overline{\psi}$, where Home and Foreign profits are equal. It follows that there is a cutoff $\psi(z)$ such that for $\psi < \psi(z)$ asymmetric equilibria do not exist.

Proposition 2 implies that when countries are sufficiently integrated (though not perfectly integrated), only symmetric equilibria exist. They either panic at the same time or neither of them panics. When the two economies are sufficiently interconnected, there does not exist an equilibrium where one expects a depressed future state of the economy and the other expects a normal state of the economy. A panic is therefore necessarily a global panic, with an equal drop in consumption, investment, output and profits across both countries.

C. *Vulnerabilities*

The model discussed so far is consistent with a synchronized decline of business cycles and profits that we saw during the Great Recession. We can connect more closely to the Great Recession by introducing considerations of firm credit. As emphasized in the introduction, the evidence does not suggest that the recession was caused by a sudden sharp drop in credit. However, well before the steep drop in output in the fall of 2008, credit became tight as a result of the falling values of real estate and other types of fixed capital. This lead to balance sheet losses in the financial sector and also reduced collateral for borrowing. From the perspective of the fall of 2008 one can then think of tight credit as a background condition, a model parameter, rather than a shock.

In order to see how tight credit may have played a role, assume that firms are credit constrained and can borrow a maximum of d in real terms in period 1. A low value of d captures in a simple way the fact that credit constraints are tight. So far we have assumed that $d = 0$, so that firms cannot borrow at all. The only impact that this has in the model is on the ability of firms to pay the continuation cost z that leads to the high productivity in period 2.[14] Therefore $A = 1$ if $\pi + d \geq z$, and $A = A_L$ if $\pi + d < z$.

When d is large enough such that

$$\frac{A_L}{\theta\lambda}\left(1 - \frac{A_L}{\theta}\right) + d \geq z \tag{41}$$

profits plus potential borrowing will be larger than z even when $A = A_L$. Therefore a global panic equilibrium does not exist as firms are better able to withstand a drop in demand that lowers first-period profits. While it remains the case that conditions in period 2 affect consumption in period 1, the linkage in the other direction is broken under loose credit conditions. Therefore, only when credit is tight (d is low) are the economies subject to a global panic.

It is also easy to see that asymmetric panics will not happen either when (41) holds. Consider again Figure 4, which considers the equilibrium $(A, A^*) = (A_L, 1)$. Equation (41) implies that when $\psi = 1$, $\pi_1 + d \geq z$. Since π_1 rises as ψ drops, $\pi_1 + d \geq z$ for all values of ψ. This is inconsistent with an equilibrium where the

[14] The bond market clearing condition will now be $B = D$, where $D = P_1 d$ is nominal borrowing, while in the budget constraint the dividend that consumers receive is the cash flow $\Pi_1 + D$ in period 1 and $\Pi_2 - (1 + i)D$ in period 2. Nothing changes once bond market equilibrium is imposed.

Home country panics and $A = A_L$. It follows that when d is large enough only a global no-panic equilibrium exists, where $A = A^* = 1$.

In a previous draft of this paper, Bacchetta and van Wincoop (2014), we also consider other types of vulnerabilities that were at play during the Great Recession. We show that both monetary and fiscal policy may have played a role. Intuitively, when the natural real interest rate is low, again as a background condition rather than a new shock, there is little that the central bank can do in terms of lowering the real interest rate without running into the ZLB. Countercyclical monetary policy will therefore be of limited use in avoiding a panic. Similarly, while we show that in principle strong countercyclical fiscal policy could avoid a global panic, fiscal policy was constrained by historically high public debt levels even before the Great Recession hit.

Finally, a key parameter is the extent of international integration. The model shows that the world becomes vulnerable to coordinated global panics only when the extent of integration is sufficiently high. Increased global integration in the decades prior to the Great Recession is an additional element, which explains why vulnerability to a global panic was high during the Great Recession.

III. Conclusion

The paper is motivated by the close business cycle co-movement during the Great Recession in a world where both goods and financial markets are far from perfectly integrated. Even though the housing and financial shock originated in the United States, business cycles in the rest of the world were impacted to a similar extent. Given limited trade and financial integration across countries, this is surprising as standard models with exogenous shocks and limited integration generate only partial transmission. It is also surprising given the much lower co-movement of business cycles during prior recessions.

To explain this we have developed a two-country model with self-fulfilling business cycle panics. We have shown that the model is consistent with high international co-movement observed during the Great Recession. We find that limited economic integration is sufficient to assure that a panic, when it occurs, is necessarily perfectly synchronized across countries. In a panic there is an equal drop of consumption, investment, output, expected output and profits across countries.

At the same time, we shed light on the fact that such strong business cycle co-movement as seen during the Great Recession is historically unusual. Many elements were in place to make such a large globally coordinated panic possible. First, there was an unusually strong trigger event for a panic in the form of US financial market turmoil, although that lies outside of the model. Second, tight credit as a result of the drop in house prices since 2006 lead to an environment where firms became very vulnerable to such self-fulfilling shocks. The fact that the hands of policymakers (monetary and fiscal) were largely tied did not help either. Finally, the gradual increase of international integration over many decades, though well short of perfect integration, made the world particularly vulnerable to a global as opposed to country-specific panic.

The model can be extended in many interesting ways. In Bacchetta and van Wincoop (2014), we show that the results continue to go through when considering financial integration and sticky wages. We also show that uncertainty about z can lead to much larger uncertainty about future income in the panic equilibrium, consistent with the second panel of Figure 2. Finally, Hausmann, van Wincoop, and Zhang (2016) consider an extension with a continuum of countries that have different levels of integration. Global panics are then coordinated only among countries whose integration level is above a certain threshold, and not for less integrated countries. They provide empirical evidence consistent with this finding.

Appendix A. GDP Forecast Expectation and Variance

This Appendix describes in more detail how the numbers in Figure 2 are computed. The data has been purchased from Consensus Economics. In their January newsletter of "Consensus Forecast" and "Asia Pacific Consensus Forecasts" they publish one-year-ahead GDP forecast probabilities since 1999 for the countries listed in the figure. More specifically, for every country and year there are seven intervals of growth forecasts (e.g., 1–2 percent, 2–3 percent). The precise intervals may change from year to year. The data reports probabilities of each interval as the percentage of forecasts that lie in that interval. We compute the expectation and variance of the forecasts by using the midpoint of each interval, together with the probabilities of the intervals.

One issue is that the intervals at both ends of the range are not bounded (e.g., an interval can be "< -1 percent"). In that case, we adopt two scenarios to choose a midpoint for the interval. In the first scenario, we choose a midpoint by assuming that the interval width is the same as that for the other intervals. In the second scenario we choose a midpoint by assuming that the interval width is twice that for the other intervals. This leads to almost identical results. Figure 2 shows the results for the first scenario.

Appendix B. Assumption 1

In this Appendix we show why Assumption 1 guarantees that firms always wish to bear the cost z if their first-period profit is sufficient to pay the cost. In order to derive this condition, we first need to derive an expression for second-period profits. Real second-period profits by firm j in the Home country are

$$\pi_2(j) = \frac{P_{H,2}(j)y_2(j) - W_2 L_2(j)}{P_2}. \tag{B1}$$

After substituting the optimal price $P_{H,2}(j) = \theta W_2/A(j)$, $L_2(j) = y_2(j)/A(j)$ and $W_2/P_2 = \lambda c_2$, we have

$$\pi_2(j) = (\theta - 1)\lambda c_2 \frac{y_2(j)}{A(j)}. \tag{B2}$$

We know that $c_2 = c_1 = c$ is equal to (31), which gives

$$\pi_2(j) = \frac{\theta - 1}{\theta} A^{\psi}(A^*)^{1-\psi}\frac{y_2(j)}{A(j)}. \tag{B3}$$

Note that we do not set $A(j) = A$ here, even though that would be the case in equilibrium, as we are considering the decision by firm j to bear the cost z conditional on what everyone else is doing.

We have

$$y_2(j) = c_{H,2}(j) + c^*_{H,2}(j) = \left(\frac{P_{H,2}(j)}{P_{H,2}}\right)^{-\mu}(c_{H,2} + c^*_{H,2}). \tag{B4}$$

Moreover,

$$c_{H,2} + c^*_{H,2} = \psi\frac{P_2}{P_{H,2}}c_2 + (1-\psi)\frac{S_2P_2^*}{P_{H,2}}c_2^* = \frac{P_2c_2}{P_{H,2}}. \tag{B5}$$

The last equality uses (25). Also using that $P_{H,2}(j) = \theta W_2/A(j)$, we have

$$y_2(j) = \left(\theta\frac{W_2}{A(j)P_{H,2}}\right)^{-\mu}\frac{P_2c_2}{P_{H,2}} = \theta^{-\mu}\left(\frac{W_2}{P_2}\right)^{-\mu}\left(\frac{P_2}{P_{H,2}}\right)^{1-\mu}A(j)^{\mu}c_2. \tag{B6}$$

Substituting $W_2/P_2 = \lambda c_2$ and the expression (27) for the relative price, we have

$$y_2(j) = (\lambda\theta)^{-\mu}c_2^{(1-\mu)\frac{\psi}{2\psi-1}}(c_2^*)^{-(1-\mu)\frac{1-\psi}{2\psi-1}}A(j)^{\mu}. \tag{B7}$$

Finally substituting the consumption expressions (31), we have

$$y_2(j) = \frac{1}{\lambda\theta}A^{1-\mu}A(j)^{\mu}. \tag{B8}$$

Second-period profits (B3) then become

$$\pi_2(j) = \frac{\theta-1}{\theta}\frac{1}{\lambda\theta}A^{\psi+1-\mu}(A^*)^{1-\psi}A(j)^{\mu-1}. \tag{B9}$$

We repeat here the condition (15) under which firm j is better off bearing the fixed cost z:

$$z < \frac{1}{1+r}\left[\pi_2(A(j)=1) - \pi_2(A(j)=A_L)\right]. \tag{B10}$$

Using that monetary policy implies $1/(1+r) = \beta$, and substituting the second-period profit expression for $A(j) = 1$ and $A(j) = A_L$, this condition becomes

$$z < \beta\frac{\theta-1}{\theta}\frac{1}{\lambda\theta}A^{\psi+1-\mu}(A^*)^{1-\psi}(1-A_L^{\mu-1}). \tag{B11}$$

We want to make sure that this always holds, independent of A and A^* and independent of ψ. Assume that $\mu > 2$. Then $\psi + 1 - \mu < 0$. We also have $1 - \psi \leq 0.5$. It follows that $A^{\psi+1-\mu} \geq 1$ and $(A^*)^{1-\psi} \geq A_L^{0.5}$. Therefore (B11) always holds when $\mu > 2$ and

$$z < \beta\frac{\theta - 1}{\theta}\frac{1}{\lambda\theta}A_L^{0.5}(1 - A_L^{\mu-1}). \tag{B12}$$

This is the condition of Assumption 1.

Appendix C. Flexible Prices

If prices in both periods are flexible, two things change. First, assuming that the central bank continues to target zero inflation, it no longer has separate control over the interest rate. The first-period interest rates i and i^* then become endogenous variables to be solved. Second, first-period prices are equal to a markup over the marginal cost analogous to the second period. This implies that (28) holds for period 1 as well, with A replaced by period 1 productivity, which is 1. It follows that $y_1 = 1/(\lambda\theta)$ and analogously $y_1^* = 1/(\lambda\theta)$. The period 1 version of (29)–(30) then implies $c_1 = c_1^* = 1/(\lambda\theta)$, so that from (33)

$$\pi = \frac{1}{\lambda\theta}\left(1 - \frac{1}{\theta}\right). \tag{C1}$$

Assumption 1 then implies that firms are able to bear the investment cost z in period 1 and therefore $A = A^* = 1$. Only the non-panic equilibrium exists. It follows from (29)–(30) that also $c_2 = c_2^* = 1/(\lambda\theta)$. As consumption is constant over time, (7) and its Foreign counterpart then imply $(1 + i)\beta = 1$ and $(1 + i^*)\beta = 1$.

Appendix D. Proof of Proposition 2

We already know that both symmetric equilibria exist under Assumptions 1 and 2. We therefore focus on the existence of asymmetric equilibria. We will only consider the asymmetric equilibrium $(A, A^*) = (A_L, 1)$ as the other asymmetric equilibrium $(A, A^*) = (1, A_L)$ exists if and only if the first one exists. In this case, profits in both countries are given by (38)–(39). We consider values of ψ between 0.5 and 1. The asymmetric equilibrium $(A, A^*) = (A_L, 1)$ exists when $\pi(\psi) < z \leq \pi^*(\psi)$. This is clearly the case for $\psi = 1$ under Assumptions 1 and 2.

Since $A_L < 1$, the derivative of π with respect to ψ is negative and the derivative of π^* with respect to ψ is positive. We will also show that there is a value $\overline{\psi} > 0.5$ for which $\pi(\overline{\psi}) = \pi^*(\overline{\psi})$. These two results together imply the proposition. As we lower ψ below 1, π rises and π^* falls, until we reach a level $\psi(z) > 0.5$ so that either $\pi(\psi(z)) = z$ or $\pi^*(\psi(z)) = z$. If this were not the case, then $\pi(\psi) < \pi^*(\psi)$ for all ψ between 0.5 and 1, which is inconsistent with the finding that they are equal for $\psi = \overline{\psi} > 0.5$. For values of ψ above $\psi(z)$, we have $\pi < z$ and $\pi^* > z$, so that $(A, A^*) = (A_L, 1)$ is an equilibrium. For values of ψ below $\psi(z)$, we either have $\pi > z$ or $\pi^* < z$, so that $(A, A^*) = (A_L, 1)$ is not an equilibrium.

We finally need to show that there is a value $\overline{\psi} > 0.5$ for which $\pi(\overline{\psi}) = \pi^*(\overline{\psi})$. $\overline{\psi}$ is given by

$$A_L^{\overline{\psi}}\left(1 - \frac{A_L^{\overline{\psi}}}{\theta}\right) = A_L^{1-\overline{\psi}}\left(1 - \frac{1}{\theta}\right).$$

This equation implies that $A_L^{\overline{\psi}} < A_L^{1-\overline{\psi}}$. Since $A_L < 1$, it follows that $\overline{\psi} > 1/2$, which completes the proof of Proposition 2.

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