# The Great Recession: A Self-Fulfilling Global Panic[1]

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**Abstract**

While the 2008-2009 financial crisis originated in the United States, we witnessed steep declines in output, consumption and investment of similar magnitudes around the globe. This raises two questions. First, given the partial integration of both goods and financial markets, what can account for the remarkable global business cycle synchronicity during this period? Second, what can explain the difference relative to previous recessions, where we witnessed far weaker co-movement? To address these questions, we develop a two-country model that allows 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. Moreover, we show that several factors generated particular vulnerability to such a global panic in 2008: tight credit, the zero lower bound, unresponsive fiscal policy and increased economic integration.

# 1 Introduction

The 2008-2009 Great Recession clearly had its origins in the United States, where an 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 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 inte-

[1] The numbers for corporate profits in the last panel of Figure 1 have been derived by aggregating profits from firms listed in the 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 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.

[3] On the contrary, Hirata et al. (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,

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

To answer these questions 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. To answer the first question, we show that expectation shocks are endogenously coordinated across countries as long as integration passes a minimum threshold. It is not possible for two countries to have very different beliefs about the future when they are sufficiently integrated. In order to answer the second question, we develop a New Keynesian model that generates vulnerability to self-fulfilling expectation shocks only under certain conditions, which are precisely ones that were present at the onset of the Great Recession. These include tight credit and constraints on monetary and fiscal policy.

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 Q3, 2008 to Q1, 2009, this view of an expectation shock

as in Devereux and Sutherland (2011), Kollmann et al. (2011) and Perri and Quadrini (2013).

[5]See Rose and Spiegel (2010), Kamin and Pounder (2012), Kalemli-Ozcan et al. (2013) and International Monetary Fund (2013).

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

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 presence of self-fulfilling expectation shocks, business cycles can be synchronized even under limited economic integration. 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 (2013a) 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.

The underlying model that is used to derive our main result is consistent with various features of the global panic in 2008. While most elements of the model are totally standard, two features generate the possibility of self-fulfilling beliefs that can give rise to a panic. First, we adopt a New Keynesian framework, where firms set prices at the start of each period. Second, we assume that 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] Lower profits also imply a greater sensitivity of firms to future shocks and therefore an increase in uncertainty about future output.

This mechanism of self-fulfilling beliefs connects to the Great Recession episode in various ways. First, it is consistent with the sharp decline in profits seen in the data, of similar magnitude in the U.S. and the rest of the world (Figure 1). Second, it is consistent with the tight credit conditions resulting from large balance sheet losses in the financial sector. We take these credit conditions as exogenous. Third, the demand shock 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), Ngyyen and Qiuan (2013)). Finally, we show that the self-fulfilling mechanism relies critically on constraints in monetary and fiscal policy. Monetary policy was constrained by the zero lower bound, while fiscal policy was constrained by historically high debt levels.

In Section 2 we present a benchmark two-country, two-period, model and show how self-fulfilling equilibria arise. This is a generic model that is not specifically developed to capture conditions during the Great Recession. Section 3 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. Section 4 brings in various features that relate the model more closely to the Great Recession. We show that countries are more vulnerable to global panics when credit is tight, monetary policy is constrained by the zero lower bound and there are constraints on fiscal policy. Section 5 considers various extensions that connect the model even more closely to the Great Recession. Section 6 concludes.

# 2 A Benchmark Model

We consider a benchmark model that illustrates the basic mechanism. There are two countries, Home and Foreign, and two periods, 1 and 2. The basic two-period

[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 Eggertsson and Krugman (2012), Eggertsson (2010) and Christiano (2004).

New Keynesian structure is similar to closed economy models found in the literature, starting with Krugman (1998).[8] Prices are pre-set, 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. As we discuss in Section 4, this simple framework can be extended in various directions, including rigid wages, government spending, investment, uncertainty, firms borrowing, financial integration, and multiple countries. 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.

## 2.1 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

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

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

[8] See Mankiw and Weinzierl (2011) or Fernandez-Villaverde et al. (2012) for recent contributions. Aghion et al. (2000) analyze a small open economy.

$c^*_{H,t}(j)$, $c^*_{F,t}(j)$ denoting the consumption of individual Home and Foreign goods consumption by Foreign households.

The parameter $\psi$ 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 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:

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

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

$P_{H,t}$ and $P_{F,t}$ are price indices of Home and Foreign goods that are denominated in respectively Home and Foreign currencies. $P_t$ 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 $\Pi_1$ and receive a transfer of $\bar{M}_1$ 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 $M_1$:

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

In period 2 Home households earn labor income $W_2(1 - l_2)$, earn a dividend $\Pi_2$, receive $(1 + i)B$ from bond holdings, carry over $M_1$ in money balances from

[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 $\psi = 0.5$.

period 1, and receive an additional money transfer of $\bar{M}_2 - \bar{M}_1$ from the central bank. These resources are then used to consume and hold money balances $M_2$:[11]

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

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

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

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:

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

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

$$c_{H,t} = \psi\frac{P_t}{P_{H,t}}c_t \quad (9)$$

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

$$\frac{W_t}{P_t} = \lambda c_t \quad (11)$$

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

## 2.2 Firms

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

$$y_t(j) = A_t L_t(j) \quad (12)$$

[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.

where $L_t(j)$ is labor input and $A_t$ is labor productivity. Productivity in period one is normalized to $A_1 = 1$. In period 2, firms can maintain this productivity level if they pay a fixed cost $z$, which is real (in terms of the consumption index). Otherwise, their productivity decreases to $A_L$. 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. Real aggregate profits in period one are given by:

$$\pi \equiv \frac{\Pi_1}{P_1} = \frac{P_{H,1}}{P_1} y_1 - \frac{W_1}{P_1} L_1 \tag{13}$$

Therefore we have

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

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:

$$P_{H,2}(j) = \theta \frac{W_2}{A} \tag{14}$$

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.

## 2.3 Central Banks

The behavior of central banks is modeled as in other two-period models (e.g., Krugman, 1998, or Mankiw and Weinzierl, 2001). The central bank in each coun-

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

try 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 $\bar{M}_2 = P_2 c_2$, 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 $i$. In most of the analysis 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 Section 4 we consider what happens when during a panic the central bank lowers the interest rate to stimulate demand. Such a policy will not avert a panic when we are close to the zero lower bound.

## 2.4 Market Clearing

For the Home country the market clearing conditions are

$$y_t(j) = c_{H,t}(j) + c^*_{H,t}(j) \quad t = 1, 2 \tag{15}$$

$$\int_0^1 L_t(j)dj = 1 - l_t \quad t = 1, 2 \tag{16}$$

$$M_t = \overline{M}_t \quad t = 1, 2 \tag{17}$$

$$B = 0 \tag{18}$$

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.

## 2.5 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 $\pi$, 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 (1) budget constraints are satisfied, (2) consumption and leisure satisfy the first-order conditions and cash in advance constraints, (3) goods, labor, money and bond markets clear, and (4) output, profits and second-period prices satisfy (11)-(13) and their Foreign analogs.*

Using straightforward algebra, Appendix B shows that all variables of the model can be written as functions of second-period productivity $A$ and $A^*$. Specifically, aggregate consumption and output, which are equal across the two periods, are

$$y = \frac{A}{\lambda\theta} \qquad y^* = \frac{A^*}{\lambda\theta} \tag{19}$$

$$c = \frac{1}{\theta\lambda} A^{\psi}(A^*)^{1-\psi} \qquad c^* = \frac{1}{\theta\lambda}(A^*)^{\psi} A^{1-\psi} \tag{20}$$

This is not a complete solution of the model though as $A$ and $A^*$ are endogenous and depend on second-period profits. As shown in Appendix B, these can also be written as a function of $A$ and $A^*$:

$$\pi = \frac{A^{\psi}(A^*)^{1-\psi}}{\theta\lambda}\left(1 - \frac{A}{\theta}\right) \tag{21}$$

$$\pi^* = \frac{(A^*)^{\psi} A^{1-\psi}}{\theta\lambda}\left(1 - \frac{A^*}{\theta}\right) \tag{22}$$

Productivity is equal to 1 or $A_L$, dependent on profits:

$$A = \begin{cases} 1 & \text{if} \quad \pi \geq z \\ A_L & \text{if} \quad \pi < z \end{cases} \qquad A^* = \begin{cases} 1 & \text{if} \quad \pi^* \geq z \\ A_L & \text{if} \quad \pi^* < z \end{cases} \tag{23}$$

Equilibria of the model then involve a set $\{A, A^*\}$ that satisfies (21)-(23).

# 3 Multiple Equilibria and Global Panics

Since second-period productivity can take on only two values, 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.

## 3.1 Symmetric Equilibria

It is useful to start by considering the existence of symmetric equilibria, where $A = A^*$. We will make two assumptions that guarantee the existence of both a symmetric non-panic equilibrium and a symmetric panic equilibrium:

**Assumption 1**

$$\frac{1}{\theta\lambda}\left(1 - \frac{1}{\theta}\right) \geq z \tag{24}$$

**Assumption 2**

$$\frac{A_L}{\theta\lambda}\left(1 - \frac{A_L}{\theta}\right) < z \tag{25}$$

Assumption 1 implies that without a panic 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 the value on the left hand side of the expression in Assumption 1 (no panic) to the left hand side of the expression in Assumption 2 (panic).

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.

## 3.2 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 (21)-(22) it follows that in such an equilibrium Home and Foreign profits are

$$\pi = \frac{A_L^{\psi}}{\theta\lambda}\left(1 - \frac{A_L}{\theta}\right) \tag{26}$$

$$\pi^* = \frac{A_L^{1-\psi}}{\theta\lambda}\left(1 - \frac{1}{\theta}\right) \tag{27}$$

The asymmetric equilibrium exists when

$$\pi < z \leq \pi^* \tag{28}$$

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 that the Foreign country does not panic as its profits are at least $z$, so that it will invest. Using the profit expressions (26)-(27) and the condition (28), 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 $\pi$ and $\pi^*$, given by respectively (26) and (27), as functions of $\psi$. The latter ranges from 0.5 (perfect integration) to 1 (autarky). Assumptions 1 and 2 imply that (28) is satisfied under autarky. Indeed, when $\psi = 1$, $\pi < z$ corresponds to Assumption 1 and $\pi^* \geq z$ corresponds to Assumption 2. 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 $\psi$ are immediate from (26) and (27). First, Home profits depend negatively on $\psi$ and Foreign profits depend positively on $\psi$. The more integrated countries become (the lower $\psi$), 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 $\psi < \bar{\psi}$, which is the level of $\psi$ where the two profit schedules cross, as then Home profits are higher than Foreign profits. More generally (28) is not satisfied for $\psi$ less than a cutoff $\psi(z)$ that lies somewhere between $\bar{\psi}$ and 1. This is illustrated in Figure 4. When $z = z_1$, the cutoff for $\psi$ is $\psi_1$. 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 $\psi$ is $\psi_3$. 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 $\psi$ occurs when $z = z_2$, in which case the cutoff is $\psi = \bar{\psi}$, 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.

# 4 Vulnerabilities

The model discussed so far is consistent with a synchronized decline of business cycles and profits that we saw during the Great Recession. However, the model is generic and not specifically aimed at describing specific events. For example, the joint conditions in Assumptions 1 and 2 that make countries vulnerable to self-fulfilling panics have little meaning in the context of the Great Recession. We will now discuss various extensions that make more transparent the vulnerabilities to such expectation shocks in 2008-2009. There are three ways in which the world economy was particularly vulnerable to a self-fulfilling panic in 2008. First, credit was known to be tight due to large losses experienced by banks and other finan-

cial institutions since early 2007, leading to deleveraging in the financial system. Second, interest rates around the world were close to zero even prior to the Fall of 2008, leaving central banks little room to maneuver. Third, the Great Recession took place against the backdrop of high levels of government debt, which limited the ability of fiscal authorities to respond with strong countercyclical policies.[13] Moreover, several countries had adopted fiscal rules, also limiting the flexibility of fiscal policy. These three factors, combined with increased global economic integration in recent decades, made the world particularly vulnerable to a global panic.

In what follows we will only consider global panics, assuming symmetry of parameters and policies across countries. It is easy to show that it remains the case that panics cannot be asymmetric when countries are sufficiently integrated.

## 4.1 Credit

Credit is not present in the benchmark model. However, we could allow for the possibility that consumers lend to firms. Assume that firms are credit constrained and can borrow a maximum of $d$ in real terms in period 1. 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

$$\frac{A_L}{\theta\lambda}\left(1 - \frac{A_L}{\theta}\right) + d \geq z \tag{29}$$

profits plus potential borrowing will be larger than $z$ even when $A = A_L$. Therefore a 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

[13] Even before fiscal debt around the globe rose significantly as a result of the recession itself, gross public debt as a percent of GDP stood close to 80% among advanced economies (see International Monetary Fund, 2012). With the exception of the end of World War II, this is the highest level in over a century.

[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.

broken under loose credit conditions. With a credit crunch, however, firms are in a situation similar to the benchmark model, so that self-fulfilling panics are possible.

## 4.2 Monetary Policy

So far we have assumed that monetary policy is a zero inflation policy and $(1+i)\beta = 1$, so that the non-panic equilibrium corresponds to the flexible price equilibrium. The central bank could try to avoid a crisis by lowering the nominal interest rate or by promising higher future inflation. It would only do this conditional on a panic. Appendix E shows that it remains the case that in a global panic $c_2 = y_2 = A_L/(\lambda\theta)$. But under more general monetary policy the consumption Euler equation now implies that

$$c_1 = \frac{1}{\beta(1+i)} \frac{P_2}{P_1} \frac{A_L}{\lambda\theta} \tag{30}$$

Both lowering the nominal interest rate and setting a higher inflation target will reduce the real interest rate and therefore increase period 1 consumption.

Higher first-period consumption will raise first-period profits, which in a symmetric equilibrium is equal to (see Appendix B)

$$\pi_1 = c_1 - \lambda c_1^2 \tag{31}$$

In order to avoid a panic equilibrium, it must be the case that $\pi_1 \geq z$ if $A = A_L$. This is the case when

$$c_1 \geq c_{min} = \frac{1 - \sqrt{2 - 4\lambda z}}{4\lambda} \tag{32}$$

while at the same time $c_1$ is no larger than its non-panic level $1/\lambda\theta$. When the central bank follows the policy $(1+i)\beta = 1$ and $P_2 = P_1$, $c_1 = A_L/(\lambda\theta)$ and Assumption 2 can be written as $c_1 < c_{min}$.

However, if monetary policy can make first-period consumption at least equal to $c_{min}$, self-fulfilling panic equilibria do not exist. If the real interest rate is reduced significantly, (30) implies that $c_1 \geq c_{min}$ might hold. The countercyclical monetary policy then stimulates period 1 consumption, which raises profits and therefore avoids a panic equilibrium.

It is clear though that during the Great Recession there was not much room for central banks to conduct such countercyclical policy, making countries particularly vulnerable to global panics. First, if a country is close to the zero lower bound,

the nominal interest rate cannot be reduced very much. The increase in $c_1$ will then generally not be sufficient to avoid a panic equilibrium. This would be the case in the model when $\beta$ is only slightly below 1, so that even in the flexible price equilibrium the nominal interest rate is only slightly above 0. Second, even though the central bank could also reduce the real interest rate by promising higher inflation in period 2, this leads to well-known time consistency problems that lie outside our model. The policy would not be credible as in period 2 the central bank has no reason to stick to it.

## 4.3 Fiscal Policy

Let us consider fiscal policy in the form of government spending financed by lump-sum taxes. In order to understand the role for fiscal policy, we need to again consider its impact on profits:

$$\pi = \frac{p_{H,1} y_1 - W_1 y_1}{P_1} = y_1 \left(1 - \lambda c_1\right) \tag{33}$$

The last equality uses that the relative price $P_{H,1}/P_1$ is equal to 1 in a symmetric equilibrium and $W_1/P_1 = \lambda c_1$. Without government spending we have $y_1 = c_1$ and $c_1 = A/(\lambda\theta)$ in a symmetric equilibrium. With government spending (see Appendix E for details) it remains the case that $c_1 = A/(\lambda\theta)$, but now output is equal to $g_1 + c_1$, where $g_1$ is period 1 government spending on domestic goods.

A global panic equilibrium is avoided when $\pi \geq z$ if $A = A_L$, which now implies

$$\left(g_1 + \frac{A_L}{\lambda\theta}\right)\left(1 - \frac{A_L}{\theta}\right) \geq z \tag{34}$$

Without government spending the left hand side corresponds exactly to the left hand side of the expression in Assumption 2, which is therefore less than $z$. But clearly with sufficient government spending this equation will be satisfied. It will also be satisfied if fiscal policy is sufficiently countercyclical, so that conditional on a panic $g_1$ is significantly increased. In both cases the government operates like a buffer, making the aggregate output and profits less sensitive to a panic in the private sector.[15]

[15] Another type of countercyclical fiscal policy that will avoid the panic equilibrium is to re-capitalize firms during a panic, as with the GM bailout. More specifically, the government would need to transfer or lend $z - \pi$ to firms conditional on a panic. This would preclude the panic equilibrium altogether.

As already pointed out though, the high levels of public debt in many parts of the world made it difficult for governments to act quickly in a strongly counter-cyclical manner, leading the world economy to be more exposed to self-fulfilling expectation shocks.

# 5 Discussion of Other Extensions

In a previous version of this paper, Bacchetta and van Wincoop (2013b), from hereon BvW, we developed several other extensions. Without getting into the algebra here, we will briefly discuss three of these extensions. We will also discuss an extension taken up in the follow-up paper by Hausmann, van Wincoop and Zhang (2014), from hereon HvWZ. All of these make the model more realistic and connect the framework even more closely to the events of the Great Recession.[16]

## 5.1 Financial Integration

In the model so far the two countries trade goods but are in financial autarky, which is clearly not realistic. We have seen that a limited degree of goods market integration is sufficient to guarantee that a business cycle panic is global. BvW consider how results are affected if instead there is financial integration. They only consider full risk sharing.[17]

Under complete markets the ratio of marginal utilities of consumption is equal to the real exchange rate[18]:

$$\frac{u'(c_t)}{u'(c_t^*)} = \frac{P_t}{S_t P_t^*} \tag{35}$$

This replaces the bond market clearing condition $B = 0$, which (as shown in Appendix B) implies $P_t c_t = S_t P_t^* c_t^*$.[19] Under log preferences, as we assumed, (35)

[16] Other extensions that we take up in BvW include a non-unitary elasticity of substitution between Home and Foreign goods and endogenous investment.

[17] Intermediate cases with partial financial integration can be accomplished in many ways and this is not necessarily captured well through one parameter in a way that is analogous to $\psi$ for goods market integration.

[18] Four assets are sufficient to achieve complete markets as $A$ and $A^*$ can in general each take on two values. These assets may have payoffs that for example depend on profits or output of both countries, which themselves are functions of $A$ and $A^*$.

[19] We assume that only households share risk. Firms do not have access to risksharing because of standard principal agents problems that also lead to borrowing constraints.

corresponds exactly to $P_t c_t = S_t P_t^* c_t^*$, so that financial markets are complete even under financial autarky and perfect trade integration implies perfect integration broadly. BvW consider more general preferences where the rate of risk-aversion differs from 1. In that case (35) is not the same condition as $P_t c_t = S_t P_t^* c_t^*$. Financial integration then makes a difference that affects the equilibrium.

BvW find that with financial integration, even less trade integration is needed (the cutoff $\psi(z)$ is even larger) to assure that panics are necessarily coordinated. Essentially, trade integration and financial integration are substitutes. A panic in only the Home country implies a transfer from the Foreign country to the Home country under financial integration. This transfer raises consumption and profits in the Home country and lowers consumption and profits in the Foreign country. Even with very limited trade integration, asymmetric panics will then be less likely.

## 5.2 Uncertainty

As shown in Figure 2, during the Great Recession there was not just a sharp drop in expected future income, but also a large increase in uncertainty about future income. BvW introduce uncertainty by assuming shocks to the fixed cost $z$ that agents only learn about after decisions about first-period consumption. They show that this can lead to endogenous uncertainty about second-period income and also generate another mechanism that contributes to self-fulfilling beliefs.

In the absence of a panic, when consumption and profits are high, firms are generally able to withstand even a high value of the fixed cost $z$. This therefore does not affect second period productivity and income. The uncertainty about $z$ then does not translate into uncertainty about future output. Under a panic however, consumption and profits are low and firms become a lot more sensitive to the value of $z$.

The endogenous uncertainty also contributes to the self-fulfilling mechanism itself. Without uncertainty we saw that the self-fulfilling beliefs operate through the expected level of second period income. With uncertainty, the second moment plays a role as well. Higher income uncertainty leads to lower consumption as a result of precautionary saving. This in turn lowers profits, which makes firms more sensitive to the fixed cost $z$. This generates uncertainty about period 2 productivity and output, making the belief of income uncertainty self-fulfilling.[20]

[20] A large literature following Bloom (2009) has focused on the impact of exogenous uncertainty

## 5.3 Sticky Wages

The model implies that real wages are pro-cyclical, as is standard when workers are on their labor supply schedule. This means that real wages go down during a panic. In reality it is well established that real wages are not very cyclical. During the last 4 months of 2008, in the middle of the Great Recession, real hourly earnings actually grew substantially in the United States instead of falling. One natural extension of the model is one where nominal or real wages are sticky. BvW adopt the commonly used approach of labor heterogeneity, so that workers can set their nominal or real wage in advance. This does not change anything for period 2 as there are no unexpected shocks during period 2. For period 1, it changes the expression for real profits. With a preset nominal wage rate, profits become linear in domestic consumption, whose solution as a function of second-period productivity continues to be (20).

In this case the profit schedules in Figure 4 will intersect at $\psi = 0.5$ as consumption is equal across countries under perfect integration. It will continue to be the case that panics are necessarily synchronized across the countries for sufficient integration ($0.5 < \psi < \psi(z)$), except for a knife-edge case where $z$ is exactly equal to profits in both countries under perfect integration.

## 5.4 Asymmetric Countries

In this paper we assumed that there are two countries and that all parameters are the same for the two countries. HvWZ consider an extension where there is a continuum of counties that have different levels of trade integration, uniformly distributed on an interval that ranges from autarky to perfect integration. They find that countries whose integration level is above some threshold will either all panic together, or none of them panics. For these integrated countries, panics are necessarily coordinated based on the same mechanism as in this paper. At the same time, in general at most a fraction of the countries below the integration

shocks on the business cycle. In contrast to this literature, here the uncertainty is entirely endogenous. Even though there is exogenous uncertainty about $z$, business cycle uncertainty is endogenous and only arises during a panic. Moreover, and again in constrast to the existing literature, the uncertainty is self-fulfilling. Basu and Bundick (2012) use a sticky price model to show that the increase in uncertainty had a large role in worsening the Great Recession. Ravn and Sterk (2012) focus on the impact of job uncertainty on the Great Recession.

threshold will panic. For these less integrated countries it matters little that there is a panic in the rest of the world. It affects their income, consumption and profits very little and they do not necessarily panic.

HvWZ find that this implication of the model is consistent with empirical evidence for 154 countries. The evidence shows that countries below the integration threshold, which is estimated as well, experienced a 2009 growth rate during the Great Recession that was about 4.5% higher than that of countries above the integration threshold. This estimate is highly statistically significant and robust to a wide range of controls. At the same time, standard measures of integration without a threshold (trade and cross border asset holdings as a share of GDP) have no explanatory power. One would have expected these last measures to be important if standard transmission mechanisms were at play, which are stronger with more integration.

# 6 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. We have argued that several factors made the 2008 episode particularly vulnerable to such a global panic: tight credit, very low interest rates, rigid fiscal policy, combined

with increased economic integration across countries. And of course there was an unusually strong trigger event for a panic in the form of U.S. financial market turmoil. The combination of these conditions separates the 2008 episode from previous recessions.

# Appendix

*A. GDP Forecast Expectation and Variance*

This Appendix describes in some 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%, 2-3%). 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%"). 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.

*B. Model Equilibrium*

In this Appendix we will show that all variables of the model can be solved as functions of $A$ and $A^*$. We first show that all variables can be written as functions of $c_t$, $c_t^*$, $y_t$, $y_t^*$, $A$ and $A^*$. We focus on the Home country, but analogous solutions apply to the Foreign country. We then solve for $c_t$, $c_t^*$, $y_t$ and $y_t^*$ as functions of $A$ and $A^*$.

It is useful to start with relative prices. Using that aggregate consumption can be written as $P_t c_t$, imposing equilibrium in labor, money and bond markets (equations (16)-(18)), the budget constraints become

$$P_t c_t = W_t L_t + \Pi_t \tag{36}$$

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

$$P_t c_t = P_{H,t} y_t \tag{37}$$

Next impose goods market equilibrium. Substituting (37), $c_{H,t} = \psi P_t c_t / P_{H,t}$ and $c^*_{H,t} = (1-\psi) S_t P^*_t c^*_t / P_{H,t}$ into the goods market equilibrium condition (15), we have

$$P_t c_t = S_t P^*_t c^*_t \tag{38}$$

Substituting the expressions for the price indices, this becomes

$$\frac{c_t}{c^*_t} = \left( \frac{P_{H,t}}{S_t P_{F,t}} \right)^{1-2\psi} \tag{39}$$

Using that $P_t / P_{H,t} = (S_t P_{F,t} / P_{H,t})^{1-\psi}$, (39) implies

$$\frac{P_{H,t}}{P_t} = \left( \frac{c^*_t}{c_t} \right)^{\frac{1-\psi}{2\psi-1}} \tag{40}$$

The Foreign relative prices are the reciprocal: $P_{F,t}/P^*_t = P_t / P_{H,t}$.

Using this solution of relative prices as a function of relative consumption, (9)-(10) also imply a solution of $c_{H,t}$ and $c_{F,t}$ as a function of $c_t$ and $c^*_t$. Other variables can be solved as functions of consumption, output and productivity of both countries as follows. From the production function we have $L_t = y_t / A_t$. From labor market equilibrium, leisure is therefore $l_t = 1 - (y_t / A_t)$. Central bank policy implies $i = (1/\beta) - 1$. Assuming that $\beta < 1$, we have $i > 0$ and both cash-in-advance constraints are binding. This implies $P_t c_t = M_t = \bar{M}_t$. The last equality uses money market equilibrium. Since $P_2 = P_1$, we have

$$\bar{M}_t = P_1 c_t = P_{H1} \frac{P_1}{P_{H,1}} c_t \tag{41}$$

Together with the expression for the relative price as a function of relative consumption, this solves for the money supply in both periods. From bond market equilibrium it is immediate that $B = 0$.

First-period real profits are equal to

$$\pi = \frac{P_{H,1}}{P_1} y_1 - \frac{W_1}{P_1} y_1 \tag{42}$$

This uses that first-period productivity is 1. From (37) 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

$$\pi = c_1 - \lambda c_1^2 \frac{P_1}{P_{H,1}} \tag{43}$$

Together with the expression (40) for the relative price, this becomes

$$\pi = c_1 - \lambda c_1^2 \left(\frac{c_1}{c_1^*}\right)^{\frac{1-\psi}{2\psi-1}} \tag{44}$$

Finally, we can solve for goods prices, wages and the exchange rate. It is first useful to note that $c_1 = c_2$ and $c_1^* = c_2^*$ in equilibrium. This follows form the Euler equation (7), together with the monetary policy $(1+i)\beta = 1$ and $P_1 = P_2$. This implies from (40) that $P_{H,1}/P_1 = P_{H,2}/P_2$. Since $P_1 = P_2$, it follows that $P_{H,2} = P_{H1}$, which is preset. Similarly, $P_{F,2} = P_{F1}$, which is preset. Using that $P_t/P_{H,t} = (S_t P_{F,t}/P_{H,t})^{1-\psi}$, it follows that the exchange rate is the same in both periods and equal to

$$S_t = \frac{P_{H1}}{P_{F1}} \left(\frac{P_t}{P_{H,t}}\right)^{\frac{1}{1-\psi}} = \frac{P_{H1}}{P_{F1}} \left(\frac{c}{c^*}\right)^{\frac{1}{2\psi-1}} \tag{45}$$

The second equality uses (40). Finally, from (11) the wage rate is equal to

$$W_t = \lambda P_t C_t = \lambda P_{H,t} y_t = \lambda P_{H1} y_t \tag{46}$$

The second equality uses (37).

Having established that all variables can be written as a function of consumption, output and second-period productivity in both countries, we will now solve for consumption and output as function of $A$ and $A^*$. Using (14), we have

$$P_{H,2} = \theta \frac{W_2}{A} = \theta \frac{W_2}{P_2} \frac{P_2}{A} = \theta\lambda \frac{c_2 P_2}{A} = \theta\lambda \frac{P_{H,2} y_2}{A} \tag{47}$$

The third equality uses (11) and the last equality uses (37). It is immediate that

$$y_2 = \frac{A}{\lambda\theta} \tag{48}$$

(37), together with (40), $c_1 = c_2$ and $c_1^* = c_2^*$ also implies that $y_1 = y_2$.

We can now solve for consumption in both countries as follows. (37) implies

$$c_t = \frac{P_{H,t}}{P_t} y_t = \left(\frac{c_t^*}{c_t}\right)^{\frac{1-\psi}{2\psi-1}} \frac{A}{\lambda\theta} \tag{49}$$

The last equality uses (40) and the solution for output. The analogous equation for the Foreign country is

$$c_t^* = \left(\frac{c_t}{c_t^*}\right)^{\frac{1-\psi}{2\psi-1}} \frac{A^*}{\lambda\theta} \tag{50}$$

Solving these last two equations gives equations (20). Substituting the solution for consumption into (44) gives profits as a function of second-period productivity in (21) and (22).

*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 (47) 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 (49)-(50) then implies $c_1 = c_1^* = 1/(\lambda\theta)$, so that from (44)

$$\pi = \frac{1}{\lambda\theta}\left(1 - \frac{1}{\theta}\right) \tag{51}$$

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 (49)-(50) 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 $(1+i^*)\beta = 1$.

*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 (26)-(27). We consider values of $\psi$ 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 $\pi$ with respect to $\psi$ is negative and the derivative of $\pi^*$ with respect to $\psi$ is positive. We will also show that there is a value $\bar{\psi} > 0.5$ for which $\pi(\bar{\psi}) = \pi^*(\bar{\psi})$. These two results together imply the proposition. As we lower $\psi$ below 1, $\pi$ rises and $\pi^*$ 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 $\psi$ between 0.5 and 1, which is inconsistent with the finding that they are

equal for $\psi = \bar{\psi} > 0.5$. For values of $\psi$ above $\psi(z)$ we have $\pi < z$ and $\pi^* > z$, so that $(A, A^*) = (A_L, 1)$ is an equilibrium. For values of $\psi$ 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 $\bar{\psi} > 0.5$ for which $\pi(\bar{\psi}) = \pi^*(\bar{\psi})$. $\bar{\psi}$ is given by:

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

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

*E. Monetary and Fiscal Policy*

Section 4 considers both monetary and fiscal policy. First consider monetary policy. (47) continues to hold, so that it remains the case that $y_2 = A/(\lambda\theta)$. (49)-(50) then also continue to hold for period 2. Since we consider symmetric equilibria in Section 4, $A = A^*$, so that it follows that $c_2 = c_2^* = A/(\lambda\theta)$. From (7), and its Foreign counterpart, it then follows that

$$c_1 = c_1^* = \frac{1}{\beta(1+i)} \frac{P_2}{P_1} \frac{A}{\lambda\theta} \tag{52}$$

One can then check whether a symmetric panic equilibrium exists by setting $A = A_L$ and computing profits. From (44) and $c_1 = c_1^*$, first-period profits is equal to $c_1 - \lambda c_1^2$. The conclusions in Section 4.2 then follow.

For fiscal policy the timing of taxation does not matter due to Ricardian equivalence. Assuming without loss of generality that the government runs a balanced budget, period $t$ taxation is equal to spending $P_{H,t} g_t$, where we assumed that the government only spends on the index of domestic goods. Subtracting this taxation from household income, and imposing labor, bond and money market equilibria as before, the budget constraints now become $P_t c_t = W_t L_t + \Pi_t - P_{H,t} g_t$. This replaces (36). Using $\Pi_t = P_{H,t} y_t + \Pi_t$, it follows that

$$P_t c_t = P_{H,t}(y_t - g_t) \tag{53}$$

This replaces (37). The goods market equilibrium is now $y_t = c_{H,t} + c_{H,t}^* + g_t$. Substituting (53), $c_{H,t} = \psi P_t c_t / P_{H,t}$ and $c_{H,t}^* = (1-\psi) S_t P_t^* c_t^* / P_{H,t}$, it follows that $P_t c_t = S_t P_t^* c_t^*$ still holds. Therefore the expression (40) of the relative price as a

function of relative consumption still holds. In a symmetric equilibrium relative prices are then equal to 1 ($P_{H,t}/P_t = 1$), so that (53) implies that $c_t = y_t - g_t$.

(47) now becomes

$$P_{H,2} = \theta \frac{W_2}{A} = \theta \frac{W_2}{P_2} \frac{P_2}{A} = \theta\lambda \frac{c_2 P_2}{A} = \theta\lambda \frac{P_{H,2}(y_2 - g_2)}{A} \tag{54}$$

It follows that $y_2 = g_2 + A/(\lambda\theta)$ and $c_2 = A/(\lambda\theta)$. From (7), and the assumed monetary policy, $c_1 = c_2 = A/(\lambda\theta)$. Therefore $y_1 = g_1 + A/(\lambda\theta)$. Substituting these expressions for $c_1$ and $y_1$ into the first-period profit expression (33), it is immediate that (34) is the condition under which a global panic equilibrium is avoided.

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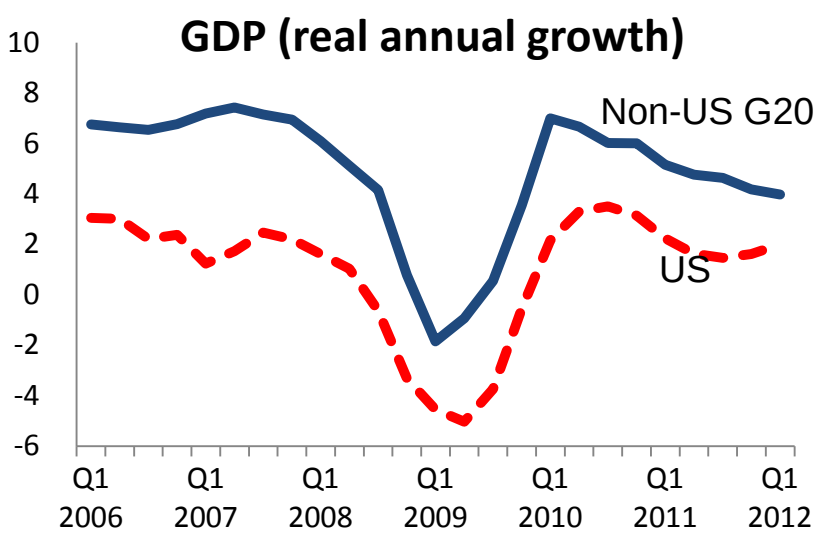
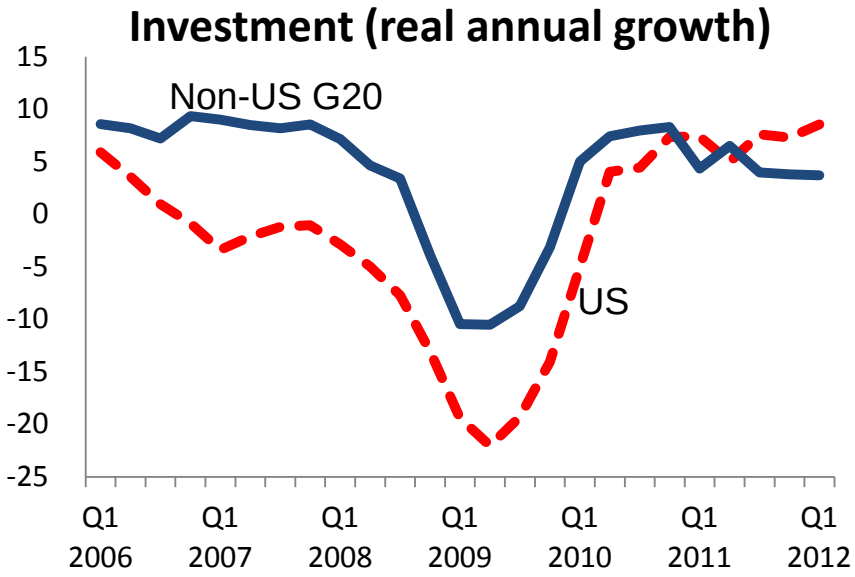
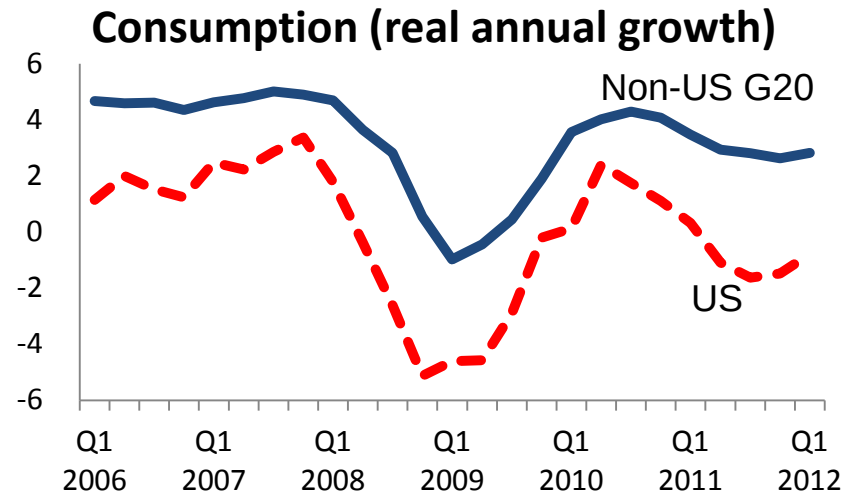
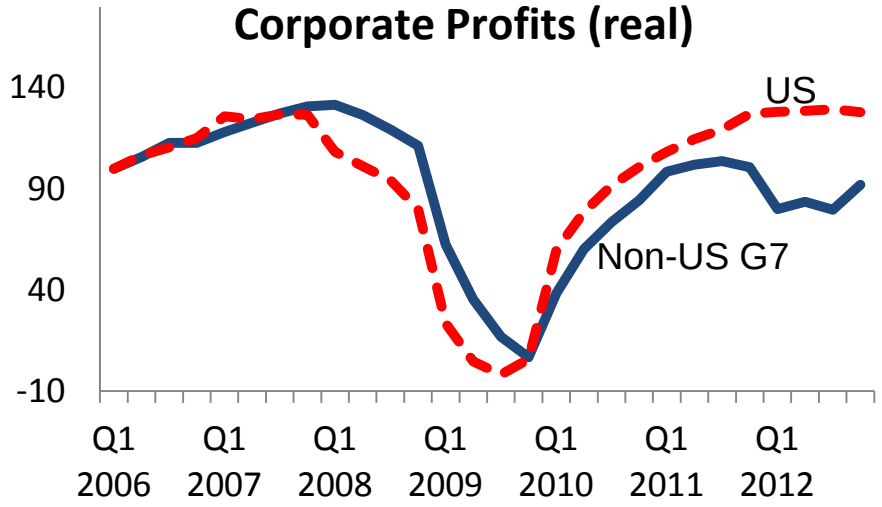
# Figure 1 Synchronized Global Recession*



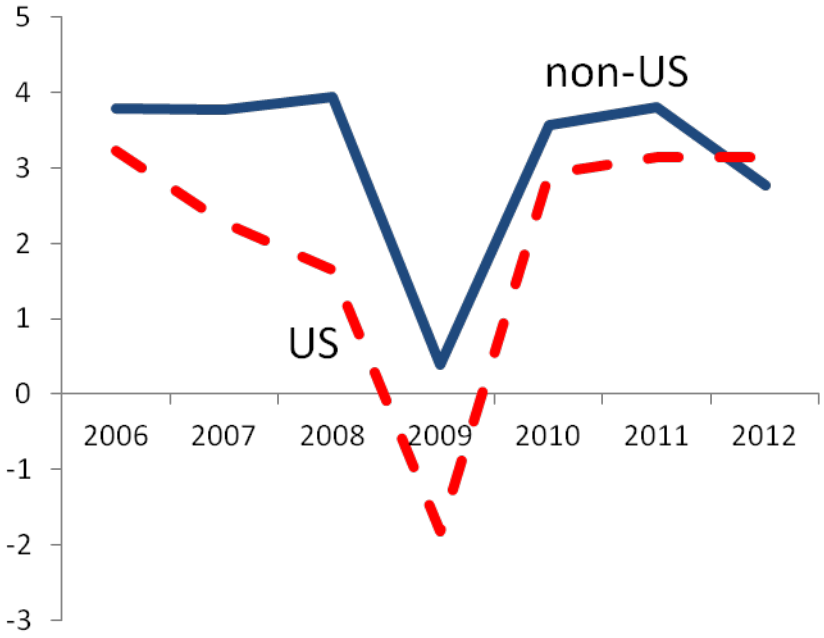



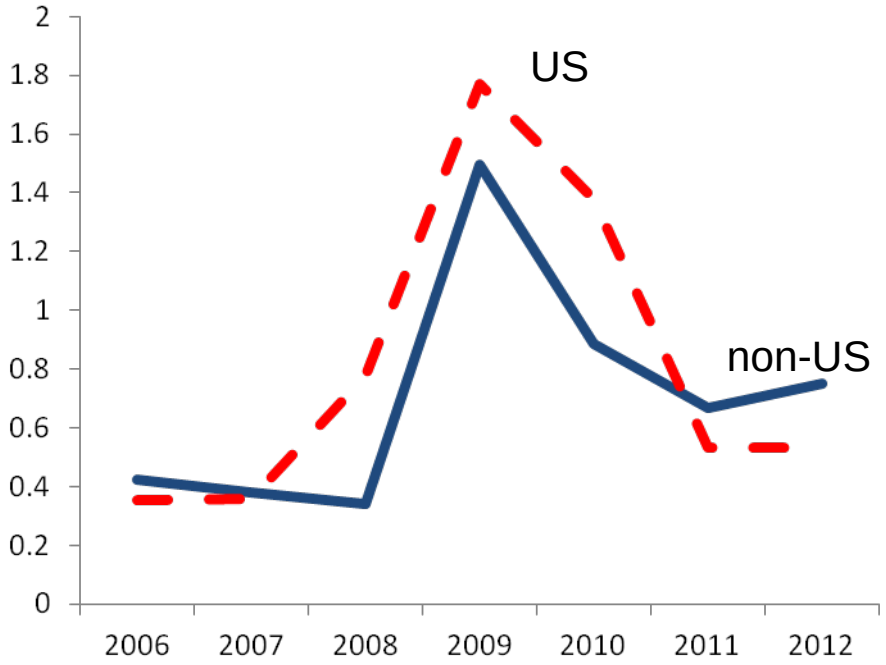

* GDP, investment and consumption are from Datastream (growth over past 4 quarters). Non-U.S. G20 excludes Saudi Arabia for GDP and also China for consumption and investment. Corporate profits are net profits from Worldscope, aggregated over continuing firms within each country, divided by the GDP deflator and normalized at 100 in 2006:Q1. Non-US G7 is computed using relative PPP-adjusted GDP weights.

# Figure 2 GDP Growth Forecasts Probabilities: Expectation and Variance*

Average Expectation

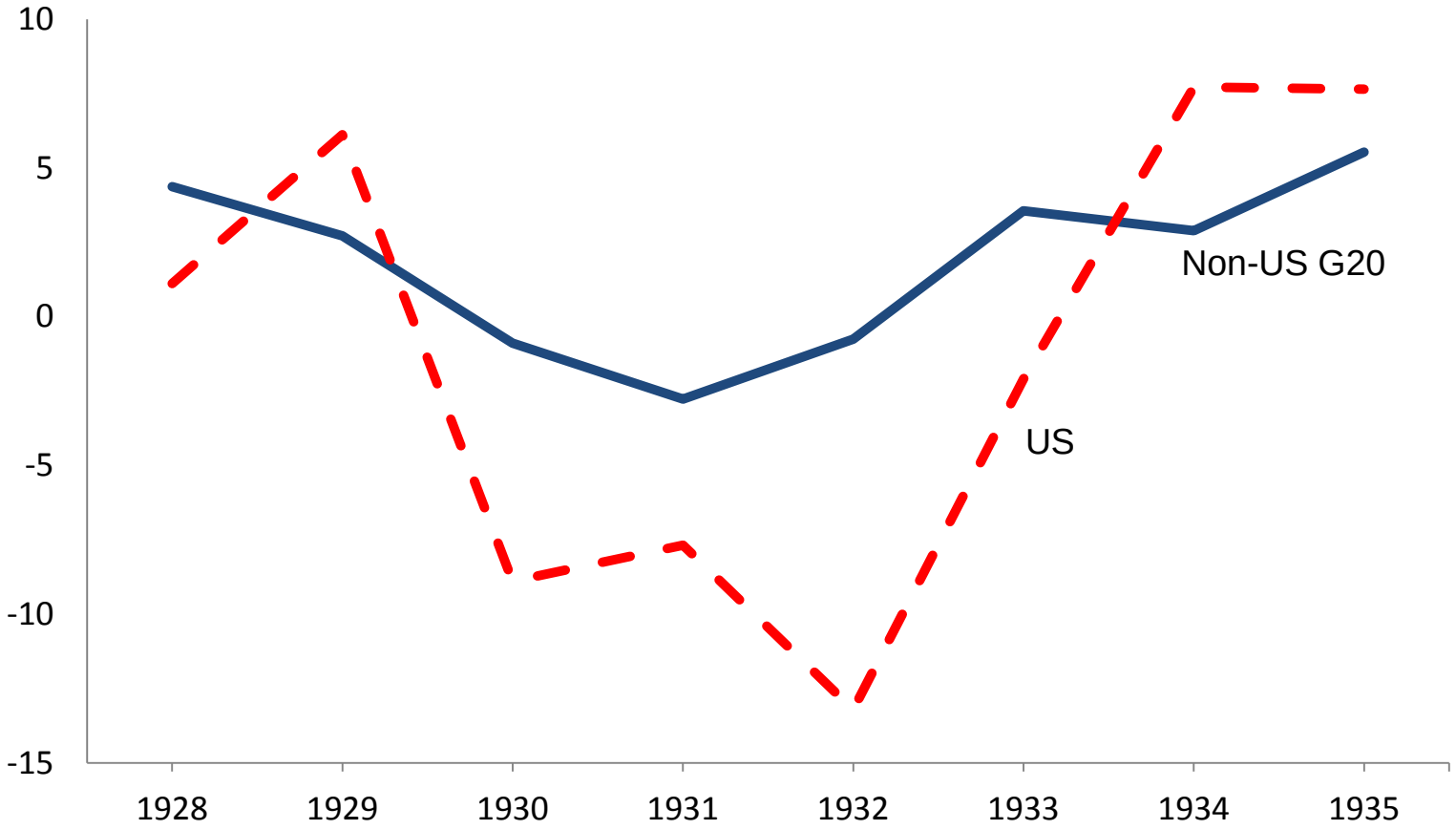



Average Variance



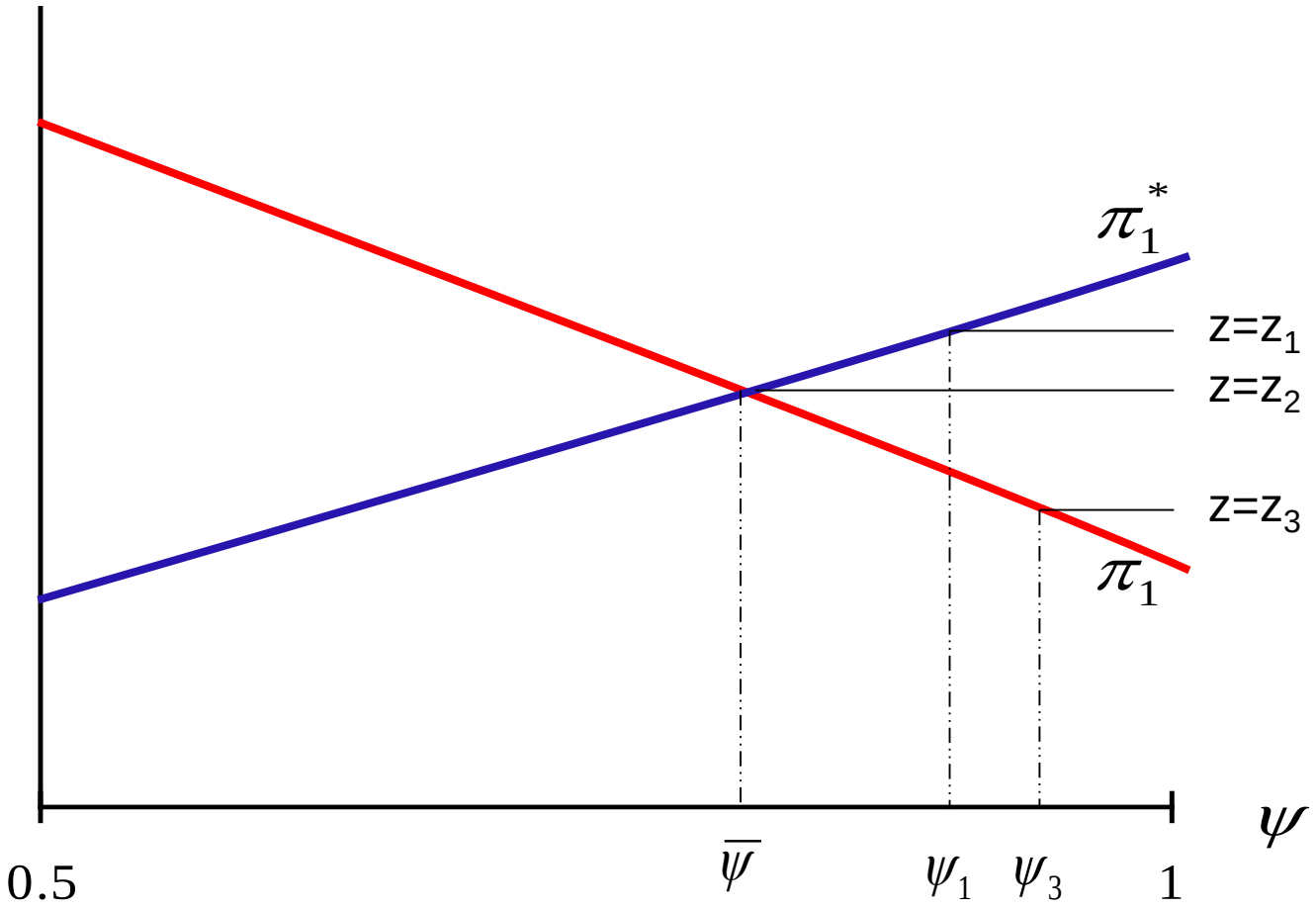

*Data from Consensus Forecasts, based on one-year ahead forecast probabilities. See Appendix A for a description. Non-US: Australia, China, Hong Kong, India, Indonesia, Malaysia, New Zealand, Singapore, South Africa, Taiwan, Thailand, Japan, Germany, France, U.K., Italy, Canada

# Figure 3 Real GDP Growth During the Great Depression




*Source: Angus Maddison. Broken line is the U.S.; solid line is the non-U.S. G20 minus Saudi Arabia minus South Africa.

# Figure 4 On Existence of Asymmetric Equilibria*




* 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 $\psi>\bar{\psi}$ .