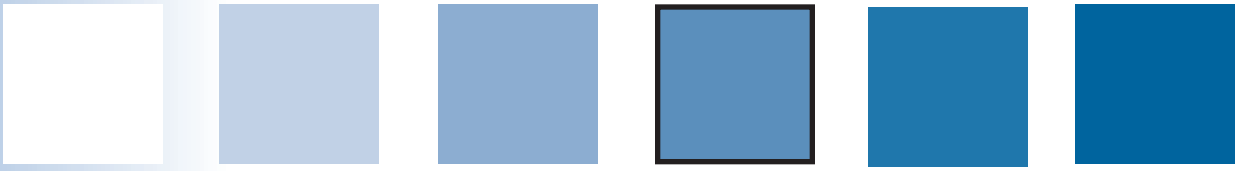
Federal Reserve Bank of St. Louis

REVIEW

July/August 2012 Volume 94, Number 4



Evolution, Impact, and Limitations of Unusual Central Bank Policy Activism

Mohamed A. El-Erian

Where There's a Smoking Ban, There's Still Fire

Michael T. Owyang and E. Katarina Vermann

The Extent and Impact of Outsourcing: Evidence from Germany

Craig Aubuchon, Subhayu Bandyopadhyay, and Sumon Kumar Bhaumik

Withdrawal History, Private Information, and Bank Runs

Carlos Garriga and Chao Gu

REVIEW

Volume 94 • Number 4

243
Evolution, Impact, and Limitations of Unusual Central Bank Policy Activism
Mohamed A. El-Erian

265
Where There's a Smoking Ban, There's Still Fire
Michael T. Owyang and E. Katarina Vermann

287
The Extent and Impact of Outsourcing: Evidence from Germany
Craig Aubuchon, Subhayu Bandyopadhyay, and Sumon Kumar Bhaumik

305
Withdrawal History, Private Information, and Bank Runs
Carlos Garriga and Chao Gu

Review is published six times per year by the Research Division of the Federal Reserve Bank of St. Louis and may be accessed through our website: **research.stlouisfed.org/publications/review**. All nonproprietary and nonconfidential data and programs for the articles written by Federal Reserve Bank of St. Louis staff and published in *Review* also are available to our readers on this website. These data and programs are also available through Inter-university Consortium for Political and Social Research (ICPSR) via their FTP site: **www.icpsr.umich.edu/pra/index.html**. Or contact the ICPSR at P.O. Box 1248, Ann Arbor, MI 48106-1248; 734-647-5000; **netmail@icpsr.umich.edu**.

Single-copy subscriptions are available free of charge. Send requests to: Federal Reserve Bank of St. Louis, Public Affairs Department, P.O. Box 442, St. Louis, MO 63166-0442, or call (314) 444-8977.

General data can be obtained through FRED (Federal Reserve Economic Data), a database providing U.S. economic and financial data and regional data for the Eighth Federal Reserve District. You may access FRED through our website: **research.stlouisfed.org/fred**.

ISSN 0014-9187

Dear Readers,

Some things change.

For many decades, we have printed and mailed the *Review* free of charge to all subscribers. We are proud of our service, but we have decided to make a change, beginning with the March/April 2013 issue:

We will cease mailing copies to subscribers outside the United States and will offer a smaller number of domestic subscriptions.

Several factors led us to this decision: our print and mailing costs (especially international postage), enhanced web-based content and delivery, and an increasingly tech-savvy readership.

Some things don't change.

Rest assured, we will maintain high standards for our content and continue our bimonthly publication schedule. As always, the most recent issue and an archive of past issues (back to 1967) are available free of charge at http://research.stlouisfed.org/. The St. Louis Fed has also developed a new publications app.

We do know that some subscribers strongly prefer a print subscription. If you are a current subscriber and wish to continue your print subscription through the mail, please re-subscribe using our online form by November 20, 2012.

https://research.stlouisfed.org/publications/review/subscribe/

We truly appreciate your readership and feedback over the years and hope you continue to read our publication and find it useful.

William T. Gavin
Review Editor-in-Chief

If you have questions, please contact George Fortier, Managing Editor, at george.e.fortier@stls.frb.org or 314-444-7320.

Evolution, Impact, and Limitations of Unusual Central Bank Policy Activism

Mohamed A. El-Erian

In the United States and Europe, central banks have essentially been the only policymaking entities consistently willing and able to take bold measures to deal with an unusually complex set of national, regional, and global economic and financial challenges since the onset of the Great Recession and financial crisis. The author advocates for other agencies, in both the public and private sectors, to urgently work in conjunction with central bank policies. He states that it is critical that policymakers, business leaders, investors, and researchers alike understand better why so many unthinkable events have become facts, why the outlook remains "unusually uncertain," and what changes are needed to limit the risks of further disruptions and bad surprises down the road. Central banks may find themselves facing one of two extremes: complementing policies by other agencies that put the global economy back on the path of high sustained growth and ample job creation or cleaning up in the midst of a global recession, forced deleveraging, and disorderly debt deflation.

Federal Reserve Bank of St. Louis *Review*, July/August 2012, *94*(4), pp. 243-64.

Good afternoon. It is a huge honor for me to be here today. At the outset, I would like to express my deep appreciation to Jim Bullard and colleagues at the Federal Reserve Bank of St. Louis. Thank you for inviting me to such a wonderful event. Thank you for the opportunity to visit this beautiful city and to reconnect with old friends and acquaintances. And thank you for allowing me to be part of this stimulating forum which, over the years, has been an important venue for debating ideas and facilitating agile intellectual interactions.

It is a particular honor to be here today for the annual Homer Jones Memorial Lecture. Mr. Jones made important contributions during his illustrious career—principally here at the St. Louis Fed but also at Brookings Institution, the University of Chicago, the Federal Deposit Insurance Corporation (FDIC), and Rutgers University. He was committed to public policy and

Mohamed A. El-Erian is chief executive officer and co-chief investment officer for Pacific Investment Management Co. LLC (PIMCO). The author thanks his PIMCO colleagues for the wonderful interactions and thought-provoking discussions over many years, with special thanks to those colleagues who offered suggestions and/or comments on this paper, including Francesc Balcells, Andrew Balls, Andy Bosomworth, Rich Clarida, Bill Gross, Scott Mather, Saumil Parikh, Lupin Rahman, Josh Thimons, and Ramin Toloui. This paper is based on the author's Homer Jones Memorial Lecture at the Federal Reserve Bank of St. Louis, April 11, 2012.

displayed leadership skills that are still admired today, some 25 years after his passing. And while I have questioned some of the assumptions that underpinned elements of Mr. Jones's work and policy advocacy over the years, I have nothing but admiration for his willingness to question conventional wisdom and official doctrine, encourage researchers to think outside the box, and engage them in open and stimulating debates.

Speaking of stimulating debates, the views that I will express today have been informed and influenced by the rich intellectual interactions that are conducted at PIMCO, my professional home. I am privileged to work in a place that embodies many of the qualities that Mr. Jones felt should dominate and persist in an institution that takes its analytical research seriously and is committed to getting things right even when this means being an outlier. The views that I will share with you are, of course, my personal ones and should in no way be deemed to reflect those of PIMCO as a firm or those of other people who work there.

I wrestled with many topics in preparation for this event. In the process, I remembered the counsel given to me many years ago by a professor when I was trying to select the subject of my doctoral thesis. He advised me that, in order to maximize the probability of success, I should be guided by two principles: Make sure to cover issues where I know more than those who will be evaluating my work and, in putting everything together, make sure that I mix and match among components that no one in their right mind would ever combine!

I did not listen to this professor's advice back in 1980 and I have not done so today. Indeed, I have gone the other way! And in so doing, I suspect that I will get very close to—and perhaps even cross, though I hope not—that delicate line that every speaker faces and fears: the one that separates courage from stupidity.[1]

Today, I will ignore the professor's advice in multiple ways. I will speak in a central bank and to central bankers about the role of their institutions—particularly the Federal Reserve and the European Central Bank (ECB)—in today's highly complex, perplexing, and historically unusual policymaking environment. I will go further and try to link actions to motivations. And, when it comes to implications, I will attempt to put forward questions and hypotheses that, I believe, are critical for the future of the United States and global economies—but for which I, like others—have only partial answers.

I do all this for a reason. I believe that, whether you look at the United States or Europe, central banks have essentially been the only policymaking entities consistently willing and able to take bold measures to deal with an unusually complex set of national, regional, and global economic and financial challenges. In doing so, they have evaluated, to use Federal Reserve Board Chairman Ben Bernanke's phrase, an "unusually uncertain" outlook[2]; they have confronted some unknowable cost-benefit equations and related economic and political trade-offs and, in some cases, they have even had to make things up as they went along (including moving way ahead of other government agencies that, frustratingly, have remained on the sidelines).

The result of all this is a global configuration of previously unthinkable monetary policy parameters. While their immediate effects may be known, the longer-term ones are less clear, and yet they are important for the well-being of millions around the world. Moreover, there is already evidence to suggest that the impact could well alter for years some of the behavioral relationships that underpin the traditional formulation and effectiveness of the trio of policies, business plans, and financial investment positioning. Accordingly, it is critical that all of us—

policymakers, business leaders, investors, and researchers—work to understand why so many unthinkables have become facts, why the outlook remains unusually uncertain, and what changes are needed to limit the risks of further disruptions and bad surprises down the road.

For those who are eager to get to the bottom line of my presentation, let me say right here that the analysis will suggest that central banks can no longer—indeed, *should* no longer—carry the bulk of the policy burden. This is not a question of willingness or ability. Rather, it is a recognition of the declining effectiveness of central banks' tools in countering deleveraging forces amid impediments to growth that dominate the outlook. It is also about the growing risk of collateral damage and unintended circumstances.

It is high time for other agencies, in both the public and private sectors, to step up to the plate. They should—indeed, *must*—use their better-suited instruments to help lift impediments to sustainable noninflationary growth and job creation. In other words, it is about improving the prospects for higher economic activity and, therefore, "safe deleveraging."

This is not to say that central banks will no longer have an important role. They will. Specifically, in what may gradually morph into an increasingly bimodal distribution of expected outcomes in some parts of the world (such as Europe), central banks could find themselves in one of two extremes: At one end, they may end up complementing (rather than trying to substitute imperfectly for) policies by other agencies that put the global economy back on the path of high sustained growth and ample job creation. At the other end, they may find themselves having to clean up in the midst of a global recession, forced deleveraging, and disorderly debt deflation.

Finally, there is a real question about how the overall global system will evolve. Most agree that its critical Western core is weakened and multilateralism is challenged. As a result, the system is likely to struggle to (i) accommodate the development breakout phase in systemically important emerging economies and (ii) absorb the deleveraging of finance-dependent advanced countries. What is yet to be seen is whether the outcome will be a bumpy transition to a more multipolar global system or the healing and reassertion of a unipolar one.

THE KEY HYPOTHESIS

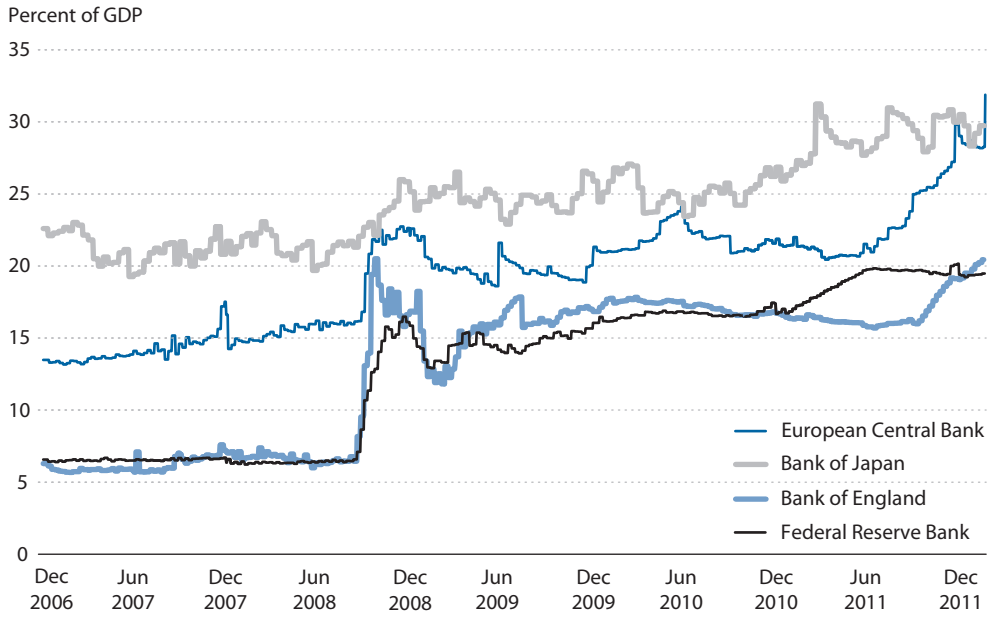
To crystallize our conversation today, allow me to use a very—and I stress *very*—clumsy sentence to summarize the current state of affairs: In the past three-plus years, central banks have had little choice but to do the unsustainable in order to sustain the unsustainable until others do the sustainable to restore sustainability!

Allow me to translate this purposely awful sentence:

- Central banks have had to innovate and stretch policy tools and mandates, including the use of liquidity facilities and communication, to render less disorderly a set of fundamental multiyear economic and financial realignments.
- While initially successful—indeed, critical to avoid a global depression—the policy stance, both here in the United States and over the Atlantic in Europe, appears now to increasingly involve an unfavorable change in the balance between what Chairman Bernanke has labeled as the benefits, costs, and risks.[3]

Figure 1

Balance Sheet (as percent of GDP)



SOURCE: PIMCO, European Central Bank, Bank of England, Federal Reserve, and Bank of Japan.

- Having built a bridge for other policymakers and for healthy balance sheets in the private sector, central banks must now hope that a more timely, comprehensive, and effective response will finally be forthcoming (and push for it, as appropriate).
- Should this fail to materialize, central banks risk finding themselves having built expensive bridges to nowhere and, accordingly, will come under severe pressure with implications for the future of central banking itself, as well as for the welfare of economies at the national, regional, and global levels.
- Meanwhile, the ripple effects from central bank policies will increasingly be felt in the functioning and, in some cases, viability of whole segments of the financial markets—thus adding to the need for both public and private entities to become more intellectually and operationally agile.

A BRIEF AND INCOMPLETE SNAPSHOT OF THE UNUSUAL ACTIVISM OF CENTRAL BANKS

The best way to get a handle on the unusual activism of central banks is to look at Figure 1. Central banks in advanced economies have ballooned their balance sheets to previously unthinkable levels—be it an astonishing 20 percent of gross domestic product (GDP) for the Fed or 30 percent for the ECB.

These unprecedented—indeed, improbable—numbers have been accompanied by other steps also deemed unthinkable not so long ago. In the case of the Fed, the securities purchase program (the second round of quantitative easing [QE2]) has been supplemented by "Operation Twist" and the aggressive use of communication, including signaling that economic conditions "are likely to warrant exceptionally low levels for the federal funds rate at least through late 2014" (Federal Open Market Committee [FOMC] press release, 2012). The FOMC has also disseminated individual members' forecasts for key macro variables and the policy rate (El-Erian, 2012a).

The ECB, not so long ago considered a "Germanic" central bank, has undertaken a range of quasi-fiscal operations—from outright purchases of sovereign bonds under its Securities Markets Programme (SMP), including those subject to material credit/default risk, to a relaxation of collateral requirements and the extension to three years in the maturity of a massive 1 percent "liquidity" facility (the long-term refinancing operations [LTROs]). Having said this, the ECB has been less willing than some other central banks to completely remove credit risk from the market.

In assessing all this, and for presentational simplicity, we can think of the central banks' involvement as two distinct, but of course highly interrelated, operations since the breakout of the global financial crisis in 2007-08.[4] The first entailed crisis management, including minimizing the risk of a liquidity sudden stop[5] (and related market failures) translating into a major economic depression. The second involved maximizing the prospects for a resumption in growth, employment, and inflation containment. The first dealt primarily with the functioning of markets while the second spoke to targeting economic outcomes. Let us discuss each in turn.

The Context

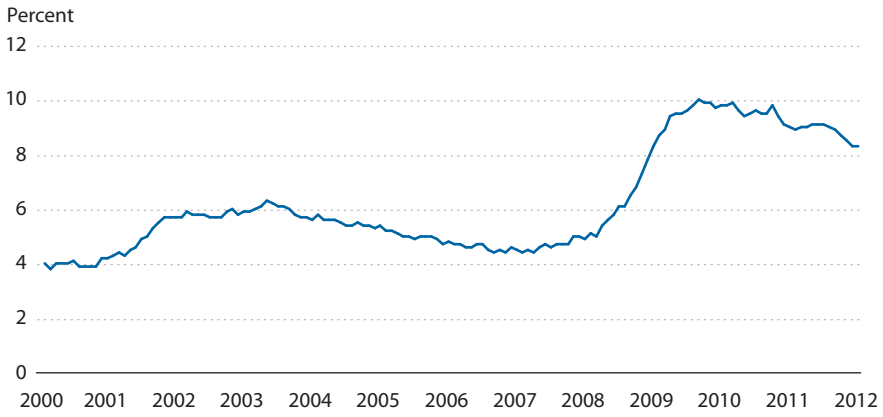
The first set of actions, be it the series of emergency facilities activated by the Fed in late 2008–early 2009 or the steps taken by the ECB back then and again more recently, was aimed at breaking the back of a particularly nasty set of multiple equilibria—what Olivier Blanchard, the chief economist at the International Monetary Fund (IMF), described as "self-fulfilling outcomes of pessimism or optimism, with major macroeconomic implications" (Blanchard, 2011).

Think here of the series of path-dependent outcomes that have usually occurred in the debt crises experienced by emerging economies. As shown in a recent paper (El-Erian and Spence, 2012), the underlying dynamics combine endogenous expectation formation with influences on behavior and hence market outcomes. These dynamics are subject to overshoots in the absence of credible circuit breakers. Specifically, a move to a bad (good) outcome increases the probability of a subsequent movement to an even worse (better) situation. It becomes even more difficult for policymakers to agree on the analysis, let alone the solutions. Meanwhile, the social and political costs increase in a nonlinear fashion, making it even harder to recover quickly.

The emphasis in such situations is (i) to boldly break the path-dependent dynamics and (ii) to do so by directing emergency policy measures to address specific market failures as well as strengthening firewalls. General Colin Powell's doctrine is often used here as a guiding principle, including its important qualifier about avoiding costly entanglements via plausible exit strategies alongside a clear intention for such interventions to be both temporary and reversible (see Cohen, 2009).

Figure 2

U.S. Unemployment Rate



SOURCE: Bureau of Labor Statistics (as of February 29, 2012).

This phase was highly effective in the United States. Think of the Commercial Paper Funding Facility and other measures deployed in the fourth quarter of 2008 and the first quarter of 2009. Starting from a situation where large and multiplying market failures were fueling sudden stops around the world, these policy measures contributed to the return of a more "normal" functioning of markets and, as such, both the disturbance and the policy measures proved largely temporary and reversible, thereby allowing for a handoff back to the private sector.

In Europe, the outcome has been more mixed. The ECB's ample liquidity provisions, and in particular the powerful 3-year LTROs, had a significant impact on bank liquidity and meaningful segments of the sovereign debt markets. Yet they failed to provide a panacea for insolvency risk, exit risk, and insufficient growth. As a result, some market segments remained impaired. Too many participants still preferred to face the ECB as a counterparty, as opposed to facing each other. Moreover, with the debt crisis still ongoing—indeed deepening—and bank fragility not yet eliminated, it is too early to make a definitive assessment.

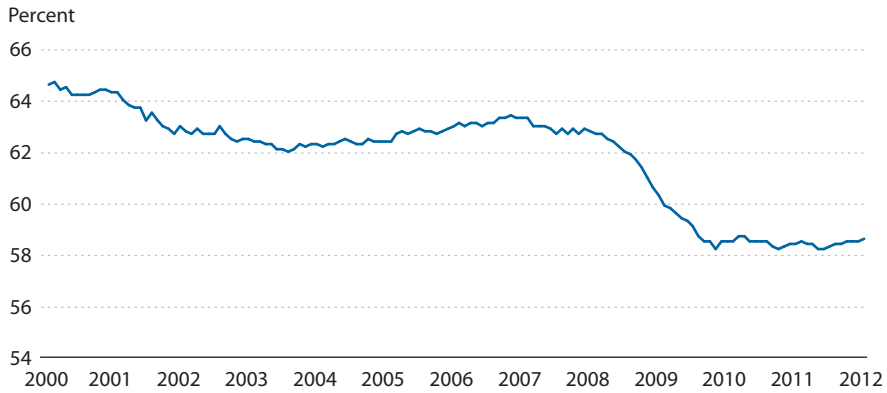
Now for the experience with the second phase—that aimed at securing certain economic outcomes. In the United States, outcomes have generally been disappointing, both in an absolute sense and, equally importantly, relative to the expectations of policymakers themselves. Just witness the frustrating persistence of unemployment at a very high rate (Figures 2 and 3) and the very disturbing long-term component (Figure 4).

As a result, discussion last year about an eventual "exit" from the FOMC's accommodative policy strategy gave way to an intensification of measures aimed at stimulating growth—be it the launch of another round of "unconventional" measures or the unprecedented use of communication. Indeed, as shown in Table 1, the 2011-12 pivot in the FOMC narrative has been quite remarkable.

Interestingly, this pivot was not related to the Fed's ability to influence market valuations in a significant manner and for a substantial period of time. Indeed, the Fed has repeatedly been

Figure 3

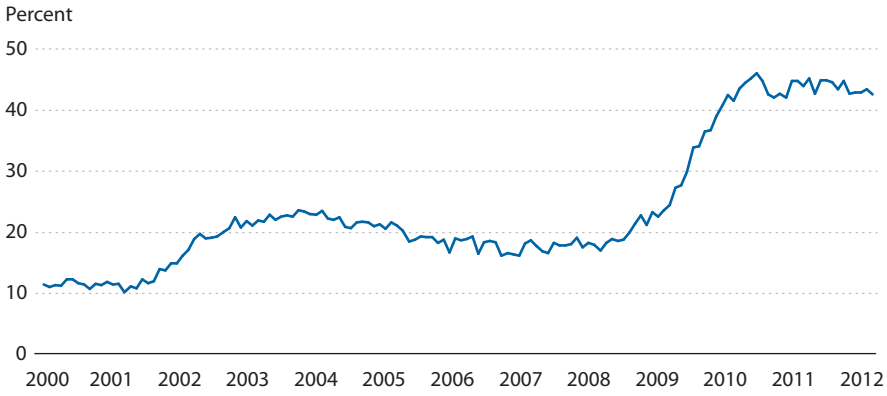
U.S. Employment (as percent of adult population)



SOURCE: Bureau of Labor Statistics (as of February 29, 2012).

Figure 4

U.S. Long-Term (≥27 Weeks) Unemployment Rate (as percent of unemployed)



SOURCE: Bureau of Labor Statistics (as of February 29, 2012).

Table 1

How the Fed's Posture Has Changed

March 15, 2011, FOMC Minutes	January 24-25, 2012, FOMC Minutes
"Economic recovery is on a firmer footing"	"Economic activity continued to expand moderately, while global growth appeared to be slowing"
"The Committee would continue its planning for the eventual exit from the current, exceptionally accommodative stance of monetary policy"	"Extending the horizon of the Committee's forward guidance would help provide more accommodative financial conditions"
"Evidence of a stronger recovery…could make it appropriate to reduce the pace or overall size of the purchase program"	"Current and prospective economic conditions…could warrant the initiation of additional securities purchases before long"
"Will pay close attention to the evolution of inflation and inflation expectations"	"The statement specifies a numerical inflation goal" of 2 percent

NOTE: The minutes of FOMC meetings are on the Board of Governors website (March 15, 2011, meeting: www.federalreserve.gov/monetarypolicy/fomcminutes20110315.htm; January 24-15, 2012, meeting: www.federalreserve.gov/monetarypolicy/fomcminutes20120125.htm).

able to turbocharge the equity markets as well as the markets for other risk assets (e.g., high-yield bonds). It has also simultaneously influenced the market for U.S. Treasury securities (Figure 5) via financial repression (Reinhart and Rogoff, 2009). The problem related repeatedly to the transmission to the real economy. Despite higher valuations, the hoped-for impact on economic activity, be it through the wealth effect or "animal spirits," has not materialized in the anticipated scale and scope.

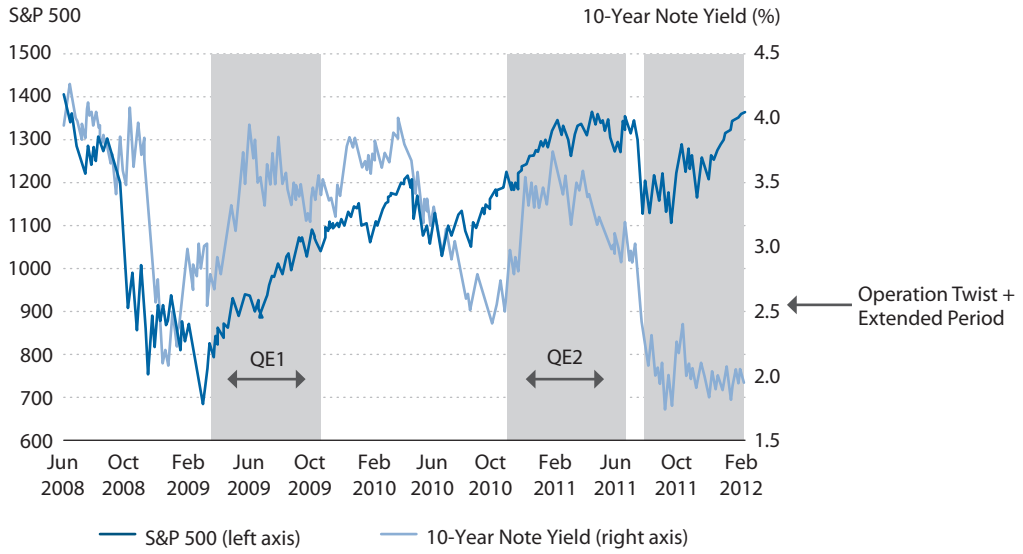
The situation in Europe has been even more disappointing. Most economic and financial indicators in the countries with the most intense crises, particularly Greece, have fallen far short of program expectations. As a result, it has taken time for official intervention to reduce regional contagion risk. And it is not just countries such as Italy and Spain that were affected and faced the risk of liquidity disruptions turning into solvency problems. The disruptions also extended to the core of the euro zone as France lost one of its AAA ratings and credit default swap spreads also widened there and in other core economies (Figure 6). Even the region's powerhouse, Germany, risks some erosion in its ability to reap the fruits of years of sustained structural reforms.

Europe's slowness in dealing decisively with its debt crisis means that some banks there continue to confront legitimate questions about asset quality and capital adequacy. And while the ECB took care earlier this year of most of the liquidity concerns through generous facilities, this measure alone cannot fully restore the normal functioning of the European banking system or ensure depositor confidence.

This landscape does not speak to the willingness and ability of central banks. Rather, it relates to the limited effectiveness that comes from the inevitability of having to deploy an imperfect, and at times experimental, policy toolkit in the face of substantial and unusual challenges.

Figure 5

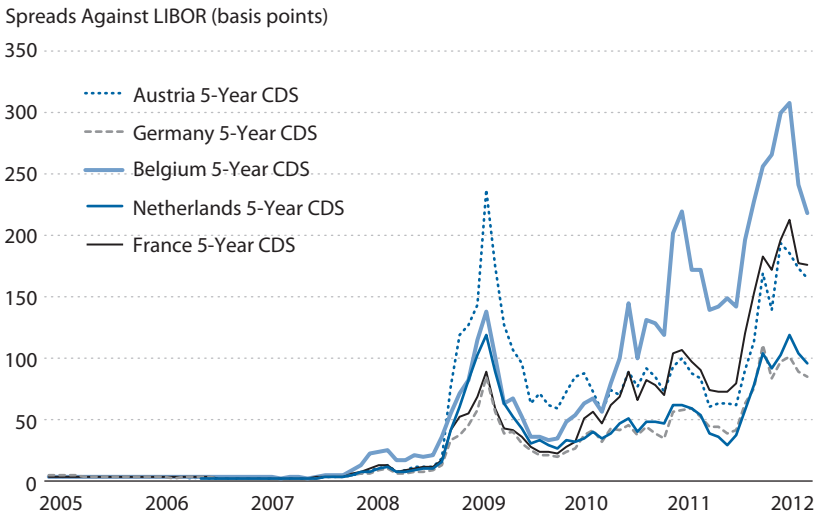
Effect of Fed Accommodation on Equities and U.S. Treasury Securities



SOURCE: Bloomberg.

Figure 6

Five-Year Sovereign CDS Spreads



NOTE: CDS, credit default swap; LIBOR, London interbank offering rate.

SOURCE: Bloomberg, Markit (as of February 13, 2012).

THE REALITY

While central banks can—and have—stabilized a range of malfunctioning financial markets, there is little they can do on their own to engineer the fundamental realignments that must accommodate seven specific dynamics in advanced economies (something we will return to later in discussing the way forward):

1. accommodating the "safe" debt deleveraging of the private sector by enabling high sustained growth
2. safely "de-risking" the financial sector
3. clearing or replacing clogged credit pipes
4. achieving a sustainable trajectory for public finances
5. improving the functioning of the labor market
6. compensating for inadequate past investments in human resources, productive capacity, and infrastructure
7. adjusting to the ongoing developmental breakout phase in several systemically important emerging countries (including Brazil, China, India, and Indonesia).

To be effective, central banks in advanced economies needed—and still need—help from other policymaking entities to confront the unfortunate twin reality of too much debt and too little growth. They must be assisted by the engagement of the healthy balance sheets around the world; fortunately, there are quite a few of them in both the public and private sectors. And this all must be done in an internationally coordinated fashion to accommodate the new global realities.

Central banks have received very little help—coordinated or otherwise—from other policy agencies. Moreover, until recently, too many of these agencies were inadvertently complicating the tasks of central banks. The contrast reflects a handful of factors:

- Many central banks—especially the Fed and the ECB—are endowed with an element of agility that most other entities, including fiscal agencies, lack. Autonomous/independent institutions can inherently move faster than elected fiscal chambers and most other regulatory agencies.
- Also, these fiscal and regulatory agencies have often failed to recognize the severity of the issues within their domain and to step up to the plate accordingly (such as in the areas of housing, housing finance, and public finance).
- Related to all this is the fact that few in government seem willing to make the range of required decisions with regard to the proper allocation of realized and prospective principal losses and, accordingly, the configuration of burden sharing.
- Faced with such difficult decisions, some political systems have shown more interest in bickering and dithering than coming together on key policy initiatives, thereby producing an unusually dysfunctional and paralyzing situation.
- The private sector has been unwilling to undertake sufficient long-term financial commitments in a world that is subject to so many moving economic, political, and regulatory pieces.

These national failures were compounded by weak policy coordination at the global and regional levels. Finger-pointing replaced the harmony achieved at the G-20 meeting in April 2009 in London. This unfortunate situation was accentuated by a distinct lack of common analysis, as well as an IMF that is still too structurally impaired and lacking sufficient legitimacy to fully step in to fill the void.

Europe was hobbled by an additional element—challenges to a "unified sovereign" process that results in cumbersome decisionmaking among, first, the 17 members of the euro zone and, second, the larger European Union collective. This political reality has severely delayed meaningful early progress toward dealing with problems not adequately considered in the establishment of the euro zone. And, as hard as it has tried, the ECB does not have the ability to influence what at times is a dysfunctional political discussion among the politicians.

THE OUTCOMES: BENEFITS, COSTS, AND RISKS

Combine all these elements and it should come as no surprise that, having spectacularly succeeded in avoiding a global depression, central banks have subsequently faced difficulties in delivering their desired economic and financial outcomes. Yet they essentially have continued on the same policy path, raising the question of whether they are subject to the trap of "active inertia."

As argued by Dan Sull (1999), active inertia has historically tripped many successful companies and poses a constant threat to others. Faced with a paradigm shift, companies respond but too often do so on the basis of what ends up being an outmoded and ineffective mind-set.

Importantly, what is at play here is not the inability to recognize a paradigm change in a timely basis; nor is it the lack of appreciation that action is needed. Rather it is the combination of such factors as inadequate strategic framing and inappropriate anchoring. The result is understandable difficulty in adjusting the set of approaches, procedures, and conventional wisdoms that previously had served the institution well.

Although central banks have succeeded in sharply curtailing the catastrophic risk of a global depression, continuation of unusual policy activism now carries risks that extend beyond the inability to deliver good economic outcomes. There are also genuine concerns that such activism involves a range of collateral damage and unintended consequences, only some of which are visible at this stage. And central banks will be questioned about whether such activism continues to be justified, given the resulting (disappointing) impact on the overall economy.

There are already visible changes to the characteristics and functioning of certain markets. As an example, consider what is happening to the money markets segment.

With policy interest rates floored at zero for such an extended period (past and also prospectively, according to recent FOMC statements; see FOMC press release, 2012a), this segment will continue to shrink—and will do so mostly from the supply side. Funds are being reintermediated to the banking sector, with a substantial portion ending up in excess reserves at the Fed. In the process, borrowers that previously depended on money market investors (think here of commercial paper issuers as an example) now need to find alternative sources of funding.

The pension industry is also increasingly challenged. At current rates, the extent of underfunding is becoming even more systemic and is being only partially compensated by the increase

in equity prices. This situation will accelerate a discussion that will be held in many circles in advanced economies: how to deal with the host of promises made at a very different economic time and that can no longer be fully met.

The functioning of markets is also changing given the size and scope of central bank involvement. The result is artificial pricing, lower liquidity, and a more cumbersome price discovery process. Moreover, participants will tell you that there are signs that the intermediaries have shifted a meaningful part of their balance sheet availability away from making markets for private sector clients to positioning for both the public sector's primary issuance and buyback activities—a perfectly rational move given that the latter has more certainty at a time of general uncertainty.

Every time central banks buy government bonds, they do more than alter the duration of financial assets held by the private sector (and credit/default risk in the specific case of the ECB's SMP). In the case of three institutions in particular (the Bank of England, the Bank of Japan, and the Fed), they also modify the balance between "safe" and other assets in the financial system (Barclays, 2012). This change has implications for collateral flows and values, as well as market positioning.

There are also implications for the behavior of market participants. The essence here was captured well in a recent investor remark reported by Bloomberg: "Investors are numb and sedated…[by the] money sloshing around the system" (Detrixhe and Krause-Jackson, 2012).

When we discuss the impact on the functioning of markets, it is important to remember that, in game theoretic terms, central banks are "noncommercial players." Their motivations and objectives differ from those of other market participants that are driven by profit and loss considerations. They pursue noncommercial objectives; they possess a printing press at their command; and they have "structural patience" that far exceeds the ability of any other participants to remain in the trade. As such, their large involvement in markets cannot but alter their functioning and what constitutes rational behavior on the part of participants.

As demonstrated in an earlier graph (see Figure 5), the previously widespread notion of a "Greenspan put" for equities has now been replaced with that of a "Bernanke put" for both equities and bonds. You will thus find a significant number of investors referring to the repeated revealed preference of the Fed as an indication that the institution is de facto committed to supporting asset valuations until they are warranted by fundamentals. In Europe, ECB-influenced moral hazard trades seem quite prevalent based on casual empiricism, especially after the LTROs.

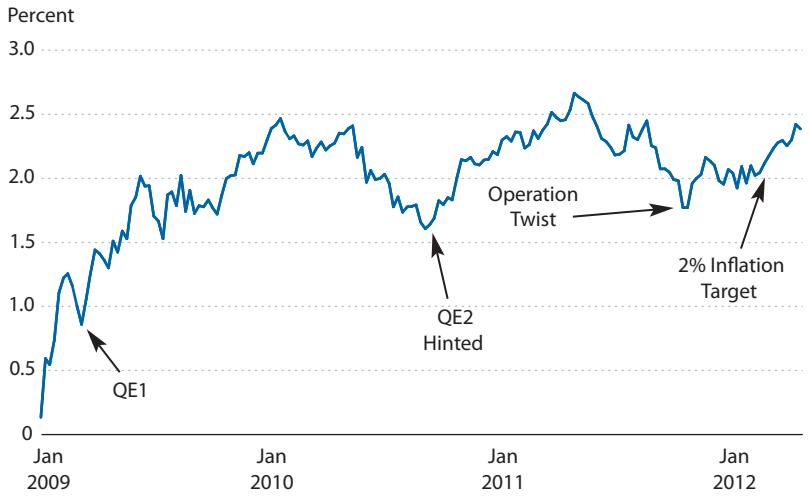
Put differently, a view has evolved that the "trading" segment of markets, whose focus is understandably short term, is now dominating the longer-term "investment" segment. This is consistent with data on market activity, how cash is allocated, and the succession of "risk on" and "risk off" sentiment. The problem with this view for the economy relates to the risk that capital allocation is distorted on both sides of the Atlantic.

I suspect that businesses and investment committees around the world are spending an unusual amount of time discussing what central banks are likely to do next. In too many cases, this discussion may overshadow those on fundamental trends, product design, and relative value opportunities. In the meantime, the incentive to self-insure against certain outcomes increases, making it harder to sustainably crowd-in long-term capital.[6]

The recurring willingness of central banks to inject liquidity is also seen by some as a contributor to higher commodity prices, especially oil and precious metals—if not directly, then

Figure 7

U.S. 10-Year Breakevens



NOTE: The 10-year breakevens are calculated by subtracting the real yield of the inflation-linked maturity curve from the yield of the closest nominal Treasury maturity. The result is the implied inflation rate for the term of the stated maturity.

SOURCE: Bloomberg (as of March 23, 2012).

indirectly by encouraging a move of financial investments into the "real asset category," which also includes Treasury inflation-protected securities (TIPS; see Figures 7 and 8 for related moves in inflation breakevens and real rates). As real and perceived risks of liquidity-induced inflation rise, more investors also opt for commodities in the hope of protecting real purchasing power. As a result, in targeting "good inflation" (namely, higher asset prices that, in turn, lead to greater investment and consumption and, accordingly, better economic outcomes), central banks have been accused of contributing to "bad inflation" (including stagflationary headwinds caused by higher commodity prices) and, ultimately, greater challenges to consumption, investment, growth, and job creation.

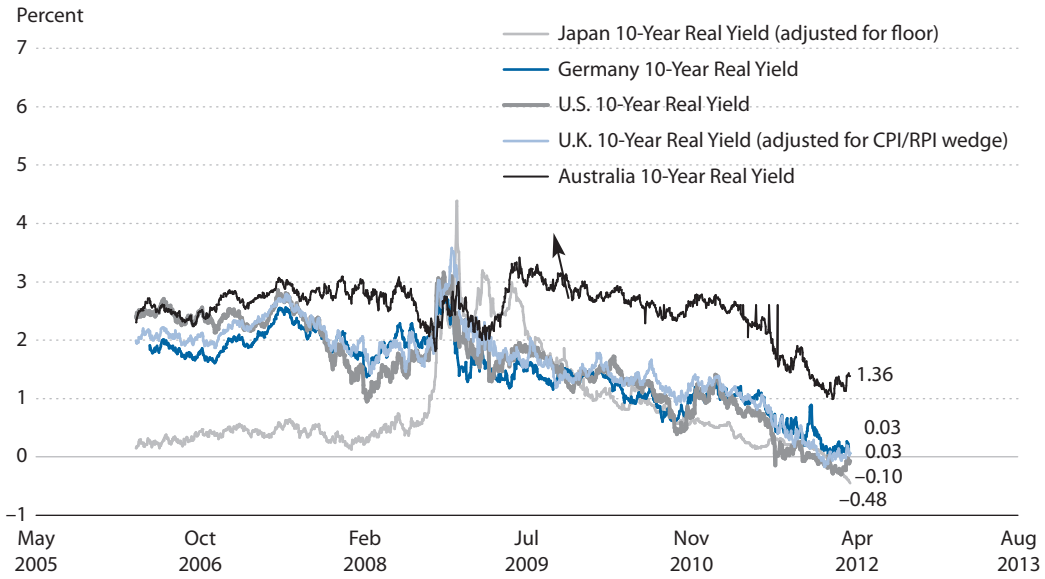
As the sizable liquidity injections cannot be fully absorbed, there is always the risk that they "leak" through the balance of payments. Indeed, several emerging economies have vocally complained about surges in capital inflows that severely complicate their own domestic economic management. The result is an intensification of currency pressures for countries such as Brazil that have already warned of the risk of a "currency war."[7]

A recent article in the *Wall Street Journal* noted, "In Brazil, the government officials blame the U.S. and Europe for lowering interest rates, and sending a wave of speculative cash its way, overvaluing its currency and hurting its competitiveness" (Lyons and Davis, 2012, p. A8). Indeed, the greater the activism of the Fed (in particular), the greater the dilemma facing other countries: They either follow the Fed or resist, but at the risk of larger distortions to their own economy.

Martin Wolf (2010), the highly respected economic commentator at the *Financial Times*, elegantly posed the dilemma as follows a couple of years ago: Given the opposing initial conditions for advanced countries and emerging ones, a policy tug-of-war was likely to develop in

Figure 8

Global 10-Year Real Yields



NOTE: Japan: Japanese inflation-linked bond (JPGi) 10-year yield (adjusted for floor); US: U.S. generic government (TII) 10-year yield; Australia: ACGBi 10-year yield; Germany: DBRei 10-year yield; U.K.: UKTI 10-year (adjusted for CPR/RPI [consumer price index/retail price index] wedge).

SOURCE: Bloomberg (as of March 23, 2012).

which the Fed would seek to de facto force a reluctant and resisting rest of the world into reflation. This would be faced initially by resistance which, de facto, involves deflationary forces.

According to Wolf (2010), this is a contest that America would win. And, so far, he is correct. A number of central banks have found themselves joining the de facto QE parade. For advanced countries, this has included both Switzerland and Japan. In the case of the former, it has involved a dramatic tweak to the "brand" of the country as the "safe haven" for financial assets; and in the case of the latter, it has involved a central bank whose governor had left no doubt in the past about his feelings about QE (see Shirakawa, 2012, and El-Erian, 2011).

Emerging economies have also been forced into monetary easing—often seen there as the "less bad" of a series of unfortunate choices prompted by advanced countries' central banks continuing to act "irresponsibly" (and certainly in a manner that was deemed inappropriate by the IMF and the United States when the emerging economies faced their own dislocations in the 1980s, mid- and late 1990s, and early 2000s). In recent weeks, we have seen a series of monetary policy easing, including measures by Brazil, Chile, China, India, Indonesia, the Philippines, Vietnam, and others.

More controversial is what happens to credit at the zero bound—something that my colleague and PIMCO's founder, Bill Gross, has been writing about recently (see, for example, Gross, 2012a,b). At some stage, zero rates combined with residual risk premiums shift inward the supply of loanable funds to such an extent that it undermines maturity extension and the

willingness to take on credit and liquidity risk. Zero rates also serve to complicate security lending, further undermining the plumbing operations that support liquidity and the sound functioning of markets.

Finally—and most controversial—the unusual activism of central banks may, at the margin, have worsened further wealth distribution. This has to do with the distribution and composition of financial wealth—in absolute terms and relative to labor income. To the extent that such policy activism succeeds in bolstering asset valuations but not the real economy, the rich benefit disproportionately more than the poor.

THE REACTION FUNCTION AND POSSIBLE MOTIVATIONS

So far, there is only limited evidence that these factors are affecting the behavior of central banks. This is not to say that recognition is lacking. It is not.

Some central banks, including the Fed and the Bank of England, have signaled their understanding of these costs and risks. This is particularly the case for the impact on pensions, money markets, and savers who rely on fixed incomes.

In the case of the Fed, Chairman Bernanke has noted that the FOMC is looking at these factors. He has added, however, that such negative externalities should be considered in the context of the need to heal the overall economy and return it to a path of high and sustained growth (see also Raskin, 2012). And the Fed has successfully cut off the horrid left tail of a debt and price deflation; that success speaks to the importance of considering such macro issues.

The case of the Bank of England could well be more nuanced at this stage. There has been active speculation about what prompted the Bank of England to announce on February 10 of this year £50 billion in additional purchases of gilts coupled with a reduction in targeted duration. Was it an improving domestic outlook, or was it the damage inflicted on the pension industry by the previous QE programs, as well as the scale of gilts already on the central bank's balance sheet?

Then there is the ECB. The dynamics there are much more complicated, especially as the constituent national central banks hold a range of views (and are subject to increased balance sheet dispersion). What is undeniable is the repeated discomfort expressed by Germany's Bundesbank, the most influential of the national banks. At times, this has resulted in public tensions with the ECB, as has the vocal involvement of politicians from both core and peripheral countries.

So, what explains the willingness of central banks to persist with an approach that, first, has disappointed in terms of outcomes and, second, is associated with such a range of collateral damage and unintended consequences? Many sitting here today are much better placed to answer this question. Indeed, analysts and observers would greatly welcome your insights on this. In the meantime, let me share with you some of the chatter in the marketplace and its implications.

LET US RECOGNIZE UP FRONT WHAT IS NOT IN PLAY

The lack of recognition by central banks that they are still far from a "first-best" policy is not at issue here. Instead, they are using imperfect instruments to deal with difficult and highly

unusual challenges. This is reflected in numerous comments made by officials on both sides of the Atlantic.

It has been suggested that the main driver of the unusual central bank activism is the combination of two factors: first, the overwhelming priority of avoiding a global economic depression and financial meltdown and, second, the belief that the response to uncertainty should not be paralysis. Together they call for repeated policy experimentation, including the incremental adaptations of the policy instruments that are available.

It has also been suggested that, with other essential policymakers missing in action (or, in the specific case of Europe, insufficiently and inconsistently engaged), it would be morally and ethically wrong for central banks to also remain on the sidelines—especially as they enjoy much greater operational flexibility and, importantly, are subject to fewer short-term checks and balances from the political system.

Finally, some argue that the central banks have reason to believe that their actions will be followed by appropriate activism on the part of other government agencies, as well as the engagement of healthy balance sheets residing in the private sector. As such, central banks' bridges will prove effective.

I suspect that most, if not all, of these factors are in play. But they are associated with a considerable risk—that of maintaining an approach that is declining in expected net benefits yet continues to take pressure off other agencies (and politicians), all of whom are more than happy to leave the central banks in the spotlight. They are being let off the hook. Rather than be viewed as having a shared responsibility, these entities would rather have central banks be perceived as owning the solution to a really complex configuration of economic, financial, institutional, political, and social challenges.

LOOKING FORWARD

Turning from the past and present to the future, three hypotheses are worth noting up front:

1. There are reasons to believe that we may be nearing the limits of net effectiveness when it comes to the current set of central bank policies.
2. Simultaneously and not unconnected, several advanced economies may be experiencing a morphing of the probability curve for expected macroeconomic outcomes—from the past of a traditional bell-shaped curve to the present of a flatter distribution with fatter tails to a bimodal distribution.
3. Regardless of how reality materializes relative to the bimodal morphing of expected outcomes, we still face some major legacy issues, the consequences of which are, as yet, difficult to specify with a sufficient degree of conviction and foundation.

Whether in the United States or Europe, government yield curves are essentially floored at exceptionally low rates up to around the 5- to 7-year point (arguably the segment of the yield curve that has the most impact on economic activity). It is also increasingly uncertain whether, at the current set of market valuations, central banks can rely just on asset purchase programs as a means of enticing investors into doing things that they would not be doing on the basis of fundamentals. Sustainability for investors is more a function of being pulled into an investment

because of its inherent attractiveness rather than being pushed into it by central banks' artificial manipulation of relative prices. Finally, there is the political angle. The unusual activism of central banks, especially components that are viewed as quasi-fiscal operations, is naturally attracting greater attention; there have been calls to subject these operations to greater parliamentary oversight, through de facto or, in some cases, de jure mechanisms.[8]

All this comes at a time when we should expect the collateral damage of central bank activism to increase. As noted earlier, this is a multifaceted issue, involving the well-being of certain sectors, the viability of historic contracts and perceived entitlements, and the very functioning of markets. And while we do not know where the exact tipping points are, few wish to get too close to them.

To put it bluntly, there are now multiple reasons to worry about the risk of central banks' expensive (and expansive!) policy bridges ending up as bridges to nowhere. In other words, there is a growing possibility that, absent mid-course corrections, unsustainability may be the common characteristic of the central banks' unusual policy activism.

Please recall the earlier discussion (see "The Reality," p. 252) of the seven dynamics driving the fundamental structural realignments facing advanced economies. This is the economic context in which central banks need to pivot from the unsustainable to the sustainable. And to do so, they urgently need (i) the cooperation of other government entities that are better placed to address what are increasingly structural impediments to growth, jobs, and better income and wealth distribution and (ii) positively correlated behavior on the part of the private sector.

In the United States, Fed measures need to be supplemented by actions in the following key areas: the labor market, public finances, housing and housing finance, credit intermediation, education and investment in social sectors, and infrastructure. For the sake of brevity, let us focus here on a subset of these key areas.

While the unemployment rate has come down in recent months—and we can argue endlessly about how much was due to genuine job creation rather than an avoidable decline in the labor participation rate—it is hard to deny that rigidities are considerable, persistent, and consequential.[9]

Recall that, according to the Bureau of Labor Statistics (2012), the number of long-term unemployed workers in the United States has been stuck at around 5½ million. The longer the duration of joblessness, the greater the risk of skill erosion and the greater the headwinds to productivity and prosperity. Or note the worrisome indicator of youth unemployment. Some 24 percent of 16- to 19-year-olds in the labor force are unemployed; at that age, persistent joblessness can turn someone from being unemployed to being unemploy*able*. Or note the sharp dispersion in the unemployment rates for different levels of education: from 4 percent for those with a bachelor's degree to 13 percent for those without a high school diploma.

Central bank actions cannot deal with these issues. Simply put, these institutions do not have the instruments or expertise to deal with the challenges of labor training and retooling. They cannot improve labor market flexibility and mobility. And they cannot influence the country's education system. Yet these challenges should—indeed *must*—be successfully confronted if we are to avoid the curse of unemployment becoming deeply embedded in the structure of the economy and, therefore, much harder to resolve.

Put housing and housing finance in the same category of importance as the labor market. There will be no durable and healthy economic recovery unless America deals with an issue that affects wealth, labor mobility, market clearing dynamics, the rule of law, and the willingness of fresh capital to engage.

Once again, there isn't much that the Fed can do beyond advocacy (something that it has been doing via speeches and a white paper; see Board of Governors, 2012). We all have to look elsewhere for an actual set of durable and effective policy measures.

Then, of course, there is the state of public finances. This is critical to both the immediate and longer-term well-being of the country. Fed officials have not been shy in emphasizing the importance of striking the right balance between immediate stimulus and longer-term fiscal reform that involves both spending and taxes. Just a few weeks ago on the Hill, Chairman Bernanke warned Congress of the dangers of a massive fiscal cliff, as well as longer-term issues of fiscal sustainability (see, e.g., Schroeder, 2012). Yet, here again, advocacy alone does not seem to go far enough. America needs both the Treasury and its politicians, especially in Congress, to get much more serious.

The ECB is in a similar dilemma—indeed, more pronounced and certainly much more urgent. It cannot deliver debt solvency and international competitiveness to peripheral economies such as Greece. Unless it is helped by others, there is likely to be a limit out there to how long it can, on its own, stop a liquidity problem in Italy and Spain from raising concerns again about solvency. And it can advocate for a stronger euro zone core but can do little to secure, to use the former French President Nicolas Sarkozy's word, the "refounding" of Europe.

Whether the ECB officials like it or not—and I would venture they do not—history books will judge the success of their unusual activism based on what other policymakers end up doing. In the meantime, Europe, like too many other advanced economies, is experiencing a consequential morphing of the shape of the distribution for expected macroeconomic outcomes.

EXPECTED DISTRIBUTION OF POSSIBLE OUTCOMES

There is a good chance that much of policymaking—and clearly the important underpinnings of conventional portfolio management—is based on a traditional bell curve governing the distribution of expected outcomes. As some of my colleagues, including Rich Clarida and Vineer Bhansali, have written, things change quite a bit when this is no longer the case (see Clarida and El-Erian, 2010, and Bhansali, 2011).

The morphing of expectation distributions is most invasive in Europe. Given the extent to which the dislocations in the periphery have contaminated the core, it is hard to see how the euro zone can maintain the status quo of the past two years. Instead, one of two scenarios may play out over time. Either European leaders are able to regain control of the situation and put the "project" on a much stronger structural and financial footing (either in its current configuration or via a smaller, stronger, and more coherent one), or they risk losing total control and seeing this important construct fall victim to disorderly fragmentation with significant costs not only for Europe, but also for virtually every country around the world.

This potentially places the ECB in an equally unsettling bimodal situation. First, it can see its bold efforts of recent years supplemented and reinforced by better policymaking elsewhere,

thereby also engaging fresh private sector capital that can serve as oxygen for the real economy and facilitate over time the resolution of the twin problem of too much debt and too little growth. Or, second, it may find itself having to help clean up a series of bank disruptions, a disorderly collapse in the demand curve for European assets (including government bonds), and, most worrisome of all, a messy return to national currencies.

The situation in the United States is less extreme, leaving the country for now more exposed to a "muddle through" scenario (though the underlying dynamics are not totally dissimilar). Policymakers here are in a better position to regain control of outcomes. By addressing the impediments listed earlier, they can encourage the engagement of significant idle private capital and place the economy back on the road to higher growth, greater job creation, financial soundness, and less-worrisome trends in income and wealth inequality. However, if they continue to dither and bicker, structural impediments will grow, will become more deeply entrenched in the construct of the economy, and will further undermine policy flexibility and effectiveness.

This bimodal situation has implications for Fed policy. In one mode, the Fed sees its unusual policy activism rewarded and ends up retaining sufficient popular and political support to allow it to pursue its dual objectives in an effective manner. In the other mode, the very independence of the Fed could be severely threatened and its policy activism could end up inadvertently associated with either stagflation or, even worse, debt deflation and recession.

What transpires in America and Europe is extremely consequential for virtually every country in the world and every market. It is not just about the largest two economic regions and, therefore, systemic demand and financial and network effects. It is also about the eventual construct of the global economy.

The functioning of today's global economy is still dominated by what is best described as a concentric circles construct. Despite its recent economic and financial challenges, the West occupies the inner circle and essentially anchors the outer circles. This Western-anchored core provides the major global public goods, has a disproportionate impact on policy agendas, and still dominates multilateral forums. While several of those in the outer circles have grown stronger and are even starting to link directly (e.g., through bilateral payments arrangements), none are in a position to move into the inner circle, nor do they wish to.

The traditional concentric construct underpinning the international monetary system persists if the weakening of the core is alleviated in the short term and meaningfully reversed over the longer term. This happens only if the Fed and ECB are supported in their policymaking role by other government entities—and supported in a manner consistent with the developmental breakout phase of systemically important emerging economies. Absent that, it is more likely that the world would undergo a messy transition to a multipolar construct whose functioning, as yet, is unclear and whose implications are uncertain though most certainly consequential.

CONCLUDING REMARKS

After diffusing a material threat of a global depression, central banks in the advanced economies did a good job in maintaining a certain status quo in the midst of too much debt, too little growth, too much inequality, and a historic global economic realignment. Critically, they succeeded in their overwhelming priority of avoiding an economic depression. Concurrently,

they reduced the risk of market overshoots and disruptive multiple equilibrium dynamics, thereby alleviating well-founded concerns about extreme negative tail-risk events, including a renewed financial meltdown.

This success involved the unprecedented use of tools available to central banks. In the process, central banks stretched like never before in the era of modern central banking the very concept of a monetary institution. And while the benefits were immediate in the crisis management phase, they have been less consistent when it comes to securing certain economic outcomes. In addition, they have come at a potential cost and with risks. They are also serving to alter behavioral relationships, change market functioning, and modify the configuration of certain market segments.

I think that we have reached the legitimate point of—and the need for—much greater debate on whether the benefits of such unusual central bank activism sufficiently justify the costs and risks. This is not an issue of central banks' desire to do good in a world facing an "unusually uncertain" outlook. Rather, it relates to questions about diminishing returns and the eroding potency of the current policy stances.

Fundamentally, what is increasingly in play today is the set of challenges facing central banks' toolkit in a world that also confronts meaningful structural (as opposed to just cyclical) and solvency headwinds. This is about the balance between continued benefits and unintended consequences/collateral damage. It also speaks to the extent to which the crutches of unusual central bank activism risk being treated as substitutes for actions by other policymaking entities, politicians, businesses, and capital markets. In sum, it is about the concept of sustainability—not only for economies but also for central banks as healthy, credible, and politically robust institutions in our national, regional, and global economies.

Where the global economy goes from here will depend less on the actions of central banks and more on whether others, including key government entities and private sector participants that have the ability to act but lack sufficient willingness to do so, finally step up to the plate. Only with the supportive actions of others can central banks pivot away from using—again, in my own clumsy terms—"the unsustainable to sustain the unsustainable" and move toward a better equilibrium for them and for the global economy (i.e., sustainability).

This need for others to step up to the plate does not mean that central banks are off the hook. Quite the contrary. In the period ahead, central banks will need to consider how best to navigate what may increasingly morph over time into a bimodal distribution for expected economic outcomes, especially in Europe. They could also find themselves countering even more complicated self-insurance behavior on the part of the private sector. And the political context could get more difficult.

Rather than lead the parade of advanced nations—which they have done so skillfully and boldly since the outbreak of the global financial crisis—central banks risk finding themselves increasingly in the position of followers. And they will do so in the context of uncertainties about the overall construct of a global economy that is now operating with a weaker traditional core but no ready and able substitutes.

The welfare of millions in the United States and Europe, if not billions of people around the world, will have suffered greatly if central banks end up in the unpleasant position of having to clean up after a parade of advanced nations that headed straight into a global recession and a

disorderly debt deflation. Let us therefore hope that central banks will, instead, find themselves part of a much broader policy effort headed toward high sustainable growth, ample job creation, less income and wealth inequality, and financial soundness.

NOTES

[1] I am grateful to Paul McCulley, my former PIMCO colleague, for first alerting me of this delicate balance.

[2] Bernanke (2010a) warned of the unusually uncertain outlook during his July 21, 2010, appearance before the Senate Banking, Housing, and Urban Affairs Committee.

[3] Bernanke (2010b, p. 12) referred to this balance—among benefits, costs, and risks—at the 2010 Jackson Hole Symposium; he also cited the balance in subsequent papers and testimonies.

[4] This paper does not deal with the role of central banks in the run-up to the 2008 global financial crisis.

[5] The concept of sudden stops was popularized by Professor Guillermo Calvo in the context of the 1980s Latin American crisis; see Calvo (1993).

[6] Note that all this is consistent with the changes in asset class correlations in capital markets.

[7] See, for example, the comments by Finance Minister Guido Mantega in Wheatley and Leahy (2011).

[8] For a recent analysis of concerns with activism, and for the case for restoring some of the old orthodoxy, see Plosser (2012). Part of this perspective is countered in another paper presented at this meeting—namely, McCulley and Pozsar (2012).

[9] For example, see El-Erian (2012b). A more detailed recent analysis is contained in Bernanke (2012).

REFERENCES

Barclays Capital. *Equity Gilt Study 2012*. Fifth-seventh edition. Barclays Bank PLC, London, 2012.

Bernanke, Ben. Semiannual Monetary Policy Report to the Congress. Testimony before the Committee on Banking, Housing, and Urban Affairs, U.S. Senate, Washington, DC, July 21, 2010a; www.federalreserve.gov/newsevents/testimony/bernanke20100721a.htm.

Bernanke, Ben. "The Economic Outlook and Monetary Policy." Presented at a symposium sponsored by the Federal Reserve Bank of Kansas City, "Macroeconomic Challenges: The Decade Ahead," Jackson Hole, Wyoming, August 27, 2010b; www.federalreserve.gov/newsevents/speech/bernanke20100827a.htm.

Bernanke, Ben. "Recent Developments in the Labor Market." Speech to the National Association for Business Economics Annual Conference, Washington, DC, March 26, 2012; www.federalreserve.gov/newsevents/speech/bernanke20120326a.htm.

Bhansali, Vineer. "Asset Allocation and Risk Management in a Bimodal World." *Viewpoints*, December 2011, PIMCO; www.pimco.com/EN/Insights/Pages/Asset-Allocation-and-Risk-Management-in-a-Bimodal-World.aspx.

Blanchard, Olivier. "Blanchard on 2011's Four Hard Truths." VOX, December 23, 2011; www.voxeu.org/index.php?q=node/7475.

Board of Governors of the Federal Reserve System. "The U.S. Housing Market: Current Conditions and Policy Considerations." White paper, January 4, 2012; http://federalreserve.gov/publications/other-reports/files/housing-white-paper-20120104.pdf.

Bureau of Labor Statistics. "The Employment Situation—January 2012." News release. February 3, 2012; www.bls.gov/news.release/pdf/empsit.pdf.

Calvo, Guillermo A. "Explaining Sudden Stop, Growth Collapse, and BOP Crisis." *IMF Staff Papers*, Special Issue 1993, *50*, pp.1-20; www.imf.org/external/pubs/ft/staffp/2002/00-00/pdf/calvo.pdf.

Clarida, Richard and El-Erian, Mohamed. "Uncertainty Changing Investment Landscape." *Financial Times*, August 20, 2010; www.ft.com/intl/cms/s/0/3ff03d10-9e53-11df-a5a4-00144feab49a.html#axzz1toQLvubw.

El-Erian

Cohen, Michael A. "The Powell Doctrine's Enduring Relevance." *World Politics Review*, July 22, 2009; www.worldpoliticsreview.com/articles/4100/the-powell-doctrines-enduring-relevance?page=1.

Detrixhe, John and Krause-Jackson, Flavia. "Iran Anxiety No Match for Central Bankers Sedating Investors." *Bloomberg News*, February 8, 2012; www.bloomberg.com/news/2012-02-08/iran-anxiety-no-match-for-central-bankers-sedating-traders-with-cheap-cash.html.

El-Erian, Mohamed A. "Learning from the 'Lost Decades,'" in Clay Chandler, Heang Chhor, and Brian Salsberg, eds., *Reimagining Japan*. San Francisco: VIZ Media, 2011, pp. 108-13.

El-Erian, Mohamed A. "The Fed Explains Its Big Adventure." *Financial Times*, February 16, 2012a; http://blogs.ft.com/the-a-list/2012/02/16/the-fed-explains-its-big-adventure/#axzz1tjCQTZJm.

El-Erian, Mohamed A. "Still Losing the War on Unemployment." *WP Opinions* (blog), *Washington Post*, February 5, 2012b; www.washingtonpost.com/opinions/us-unemployment-war-needs-more-help-from-lawmakers/2012/02/02/gIQAkQYmmQ_story.html.

El-Erian, Mohamed A. and Spence, Michael A. "Systemic Risk, Multiple Equilibria and Market Dynamics—What You Need to Know and Why." *Viewpoints*, PIMCO, March 2012; http://latam.pimco.com/EN/Insights/Pages/Systemic-Risk,-Multiple-Equilibria-and-Market-Dynamics-What-You-Need-to-Know-and-Why-.aspx#.

Federal Open Market Committee. Press Release. January 25, 2012; www.federalreserve.gov/newsevents/press/monetary/20120125a.htm.

Gross, William H. "Life—and Death Proposition." *Investment Outlook* (blog), PIMCO, February 2012a; www.pimco.com/EN/Insights/Pages/Life-and-Death-Proposition.aspx.

Gross, William H. "Zero-Based Money Is at Risk of Trapping the Recovery." *Markets Insight* (blog), *Financial Times*, February 6, 2012b; www.ft.com/intl/cms/s/0/ad537e88-4ccd-11e1-8741-00144feabdc0.html#axzz1toQLvubw.

Lyons, John and Davis, Bob. "Emerging-Market Engines Falter." *Wall Street Journal*, March 8, 2012, p. A8.

McCulley, Paul and Pozsar, Zoltan. "Does Central Bank Independence Frustrate the Optimal Fiscal-Monetary Policy Mix in a Liquidity Trap?" Presented at the Inaugural Meeting of the Global Society of Fellows of the Global Interdependence Center, "Re-Examining Central Bank Orthodoxy for Unorthodox Times," Banque de France, Paris, March 26, 2012; www.interdependence.org/wp-content/uploads/2012/03/Paul-McCulley-Fellows-Paper.pdf.

Plosser, Charles I. "Restoring Central Banks after the Crisis." Presented at the Inaugural Meeting of the Global Society of Fellows of the Global Interdependence Center, "Re-Examining Central Bank Orthodoxy for Unorthodox Times," Banque de France, Paris, France, March 26, 2012; www.philadelphiafed.org/publications/speeches/plosser/2012/03-26-12_global-interdependence-center.pdf.

Raskin, Sarah Bloom. "Accommodative Monetary Policy and Its Effects on Savers." Speech to the Y's Men and Y's Women of Westport, Westport, Connecticut, March 1, 2012; www.federalreserve.gov/newsevents/speech/raskin20120301a.htm.

Reinhart, Carmen and Rogoff, Kenneth S. *This Time Is Different: Eight Centuries of Financial Folly*. Princeton, NJ: Princeton University Press, 2009.

Schroeder, Peter. "Bernanke Warns Lawmakers Country Headed for Massive Fiscal Cliff." *On the Money* (blog), *The Hill*, February 29, 2012; http://thehill.com/blogs/on-the-money/801-economy/213351-fed-boss-warns-of-massive-fiscal-cliff.

Shirakawa, Masaaki. "Deleveraging and Growth: Is the Developed World Following Japan's Long and Winding Road?" Lecture at the London School of Economics and Political Science, January 10, 2012; www.boj.or.jp/en/announcements/press/koen_2012/data/ko120111a.pdf.

Sull, Donald N. "Why Good Companies Go Bad." *Harvard Business Review*, July-August 1999, pp. 42-52.

Wheatley, Jonathan and Leahy, Joe. "Trade War Looming, Brazil Says." *Financial Times*, January 10, 2011; www.ft.com/intl/cms/s/0/6316eb4a-1c34-11e0-9b56-00144feab49a.html#axzz1toQLvubw.

Wolf, Martin. "Why America Is Going to Win the Global Currency Battle." *Financial Times*, October 12, 2010; www.ft.com/intl/cms/s/0/fe45eeb2-d644-11df-81f0-00144feabdc0.html#axzz1toQLvubw.

Close

Mohamed A. El-Erian

CEO and co-CIO, Pacific Investment Management Co. LLC (PIMCO)

Research Focus

Mohamed El-Erian's research focuses on macroeconomic policy issues, financial markets, and debt solvency.

Where There's a Smoking Ban, There's Still Fire

Michael T. Owyang and E. Katarina Vermann

Since 2001, the pervasiveness of 100-percent smoke-free bans has increased dramatically—from 32 local laws in 2001 to 308 by the end of 2009. The authors use individual-level data from the Behavioral Risk Factor Surveillance System survey to examine the effect of these bans in workplaces, bars, and restaurants on changes in smoking initiation, continuation, and cessation. They find that, relative to increases in cigarette taxes, smoking bans do not appear to be correlated with changes in smokers' behavior. (JEL I18)

Federal Reserve Bank of St. Louis *Review*, July/August 2012, *94*(4), pp. 265-86.

As information about the health consequences of smoking emerged in the 1960s, governments at all levels began regulating cigarettes through higher taxes, advertising restrictions, and warning labels. The most recent smoking regulation trend is the rise in 100-percent smoke-free bans in public and private spaces such as bars and restaurants. These bans are primarily a public health measure intended to decrease nonsmokers' exposure to second-hand smoke. Since the early 2000s, these bans have spread at a dramatic rate—from 32 local laws in 2001 to 308 by the end of 2009. At this rate, the Centers for Disease Control and Prevention (CDC, 2011) estimates that smoke-free indoor air laws will cover the entire United States by 2020.

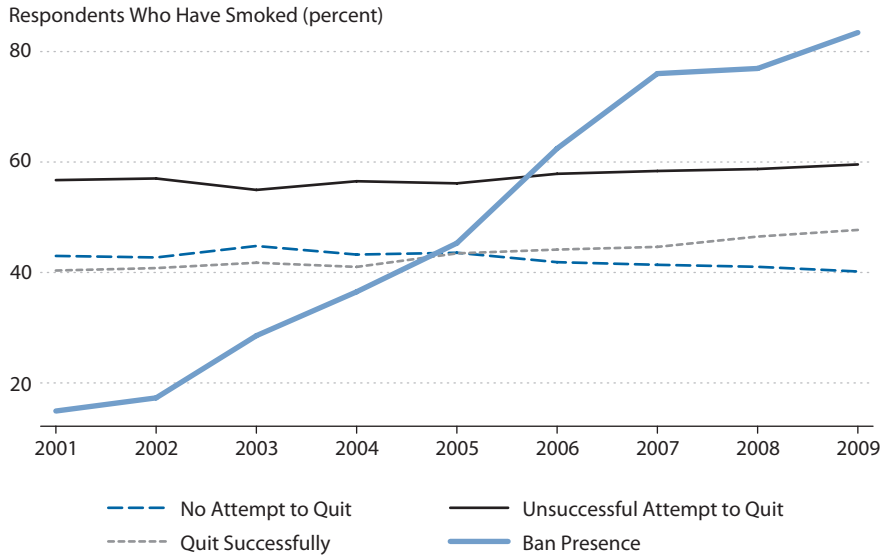
Despite the rapid spread of smoking bans, there has been little explicit discussion on their intended effects on smokers. Do bans encourage smoking cessation? Do they discourage smoking initiation among nonsmokers? Do they change public sentiment on smoking? Do they raise the opportunity cost of smoking? Preliminary data suggest that the impact of smoking bans on smokers may be limited. Figure 1 illustrates that, although the number of smoking bans has increased dramatically, smokers' habits have remained fairly constant. Over time, the data show a dramatic rise in the presence of smoking bans, a minor rise in smokers who have quit successfully, and almost no change in smokers attempting to quit. This information raises the question of whether these bans change smokers' habits.

The lack of behavioral change contrasts with the findings from previous economic studies on the effects of other forms of smoking legislation. Although 100-percent smoke-free bar and

Michael T. Owyang is a research officer and economist and E. Katarina Vermann is a research associate at the Federal Reserve Bank of St. Louis.

Figure 1

Trends in Smoking Cessation and Smoking Ban Presence



SOURCE: Behavioral Risk Factor Surveillance System survey and Americans for Nonsmokers' Rights.

restaurant bans are fairly new, economists have studied how less stringent bans in public places and workplaces have influenced smoking initiation and prevalence. The early literature—which controls for bans in examinations of tax policy and youth smoking—estimates how bans affect cigarette demand using indexes that take into account (i) ban stringency (e.g., Sung and Keeler, 1994, and Wasserman et al., 1991), (ii) the probability of encountering a ban (Yurekli and Zhang, 2000), or (iii) a combination of these two factors (Chaloupka, 1992). These analyses indicate that bans have robust, significant, and negative effects on smoking.

The assumptions surrounding the construction of these indexes, however, could have skewed results in one of two ways. Studies that weight their indexes based on the stringency of policies assume the same marginal effects for all types of bans. They also assume compliance with and complete enforcement of the restrictions (DeCicca, Kenkel, and Mathios, 2008a, and Ross and Chaloupka, 2004). On the other hand, studies with indexes that are weighted by the likelihood of encountering each specific type of ban assume that individuals respond to all bans in the same way. Yet, it has been shown that individuals who face comprehensive bans—those that cover indoor and outdoor areas—are less likely to use tobacco, but those who face indoor-only bans do not exhibit significant changes in their tobacco consumption (Knudsen, Boyd, and Studts, 2010, and Ross and Chaloupka, 2004).

Another branch of the literature on smoking bans focuses on the introduction of bans in the workplace. With the exception of Chaloupka and Saffer (1992), these studies estimate larger changes in smoking demand than studies that use indexes (e.g., Brownson, Hopkins, and Wakefield, 2002; Farrelly, Evans, and Sfekas, 1999; Irvine and Nguyen, 2011). Nonetheless, many

studies on the effects of workplace bans do not control for the presence of other bans in public places or for other aspects of tobacco control (e.g., Irvine and Ngyuen, 2011, and Farelly et al., 1999). In excluding tax rates and other venue-specific restrictions, these studies may falsely attribute the effects of other policies to workplace bans, overestimating the effect of such bans on smoking.

Finally, studies that examine the effects of smoke-free bans in bars and restaurants typically focus on the economic impact of these bans. For summaries of two different perspectives on the issue, see Scollo and Lal (2008) and Pakko (2006, 2008). Although studies of smoke-free bans find questionable evidence on the economic impact of bans largely because of limited data, they do not examine whether smoking bans stop people from smoking.

In examining the effects of 100-percent smoke-free bans in workplaces, bars, and restaurants, this paper addresses the limitations of the previous literature in three ways. First, all of the bans examined here have the same level of stringency. Second, we explicitly control for bans in workplaces, restaurants, and bars. These methods allow us to overcome the limitations of the assumed ban homogeneity in the ban index literature. Finally, we take into account other aspects of tobacco control policy, such as taxes and state-level funding. Thus, we assess the role smoking restrictions play within the myriad of tobacco control policies and determine whether they do influence smokers to change their behavior.

EMPIRICAL STRATEGY

We consider the effect of anti-smoking policies on three aspects of individual smoking behavior: *initiation*, *continuation*, and *cessation*. "Initiation" is equal to 1 if an individual responds positively when asked whether he or she has smoked at least 100 cigarettes (5 packs) in his or her lifetime; otherwise, it is equal to zero. Among the subsample of people who have initiated smoking, "continuation" equals 1 when a respondent responds positively when asked if he or she is a current smoker; otherwise, it is equal to zero. From the subsample of current smokers, "cessation" equals 1 if a current smoker has positively responded when asked whether he or she has attempted to quit smoking in the past year; otherwise, it is equal to zero.

The objective of anti-smoking policies is to raise the cost of smoking, either by increasing the nominal price through taxes levied on cigarettes or increasing the real price through smoking restrictions. When the government imposes a smoking ban, the real price of smoking increases. Rather than deciding how much to smoke based solely on the cost per pack, a smoker determines his or her optimal level of cigarette consumption by considering the opportunity cost of smoking in the presence of a ban (Irvine and Nguyen, 2011). The increased opportunity cost can reflect either the need to travel away from areas with bans to smoke or the cost of sanctions imposed for smoking within an area with a ban. Perceived social norms about smoking may also influence how an individual smoker internalizes the implicit costs of smoking in an area with a ban (Hamilton, Biener, and Brennan, 2008). Hence, large-scale changes in the public's perception of smoking—one of the goals of a smoking ban—would influence an individual's decision to smoke (Singleton, 2008; DeCicca et al., 2008b; Kim and Shanahan, 2003).

We are interested in evaluating the correlation between the presence of a smoking ban and the prevalence of each smoking behavior. In the presence of a smoking ban, one would expect initiation to decrease over time. This decrease would indicate that bans would make smoking

even less appealing, thus making the costs of smoking today outweigh the benefits. Continuation shows us whether areas with bans have more former smokers. Over time, this variable could indicate whether bans encourage current smokers to quit. Cessation shows us whether a ban is correlated with a higher proportion of individuals attempting to quit, indicating that the ban has increased the real cost of smoking. Cessation also shows us whether a ban is a good commitment device for quitting, as the individuals in the survey who have attempted to quit have not succeeded in quitting.

The treatment variables consist of a set of 100-percent smoking ban dummy variables defined for various geographic-establishment combinations. We assume a ban can affect workplaces, restaurants, or bars. We also assume a ban can be at the municipality, county, or state level. Obviously, a ban with a narrower geographic scope (i.e., a municipality) is subsumed by a ban with a wider geographic scope (i.e., a county). The wider the ban, the costlier it presumably is for the affected smoker. Thus, we also control for the ease with which an individual can avoid a ban by calculating the percentage of a population within a county or metropolitan area facing a ban.

Aside from the policy considerations, some local conditions and individual-level characteristics may affect smoking behavior. For example, we include local cigarette and beer prices; the latter are included because smoking and drinking are often thought of as complements (DiFranza and Guerrera, 1990; Bask and Melkersson, 2004; Picone, Sloan, and Trogdon, 2004). At the individual level, we include respondent age, gender, education, income, employment status, marital status, parental status, and alcohol consumption (see Dedobbeleer et al., 2004; Dodgen, 2005; Cheng and Kenkel, 2010). These characteristics are argued to serve as proxies for the individual's degree of tobacco addiction, which cannot be measured directly (Irvine and Nguyen, 2011, and Harris and Chan, 1999). Table 1 provides summary statistics for each of the variables.

We model the smoking behavior j for individual i as a function of a vector of individual-level factors, $\boldsymbol{Z}_i$, and a vector of policies, $\boldsymbol{P}_i$, that the individual faces. In $\boldsymbol{P}_i$, we consider smoking bans, the chance an individual will encounter a ban, taxes (through cigarette price per pack data, which include taxes), and state tobacco control funding. Let $S_{ij} \in \{0,1\}$ be an indicator variable that reflects whether individual i responded positively to the survey question about smoking behavior $j \in \{initiation, continuation, cessation\}$. Because the smoking behaviors are binary, we model the probability that an individual undertakes a particular smoking behavior with a binomial probit:

$$\Pr\left[S_{ij} = 1\right] = \Phi\left(\beta_z Z_i + \beta_p P_i\right),$$

where $\boldsymbol{\Phi}(\cdot)$ is the standard normal cumulative density function and the βs are coefficients.[1]

The main coefficients of interest from these estimates are those for the ban dummy variables, the probability of encountering a ban, and the cigarette price per pack. We expect these coefficients to be negative for estimations of smoking initiation and continuation but positive for estimations of cessation. Generally, the results of a probit can be used to estimate marginal effects at the means of the other covariates. However, when the probability of encountering a ban is a right-hand-side variable, the computation of the marginal effect is not straightforward. The ban encounter probability is not independent of the ban- and individual-level variables: It can change

because of changes in population, the introduction of new municipality-level bans, and individual choices (e.g., whether an individual chooses to go to a bar).

We estimate the marginal effects two ways: First, we compute the marginal effect of instituting a particular type of ban when there was no previous ban. In other words, we find the effect of switching one (and only one) of the policy variables from 0 to 1, holding all continuous variables (e.g., cigarette price) constant at the mean and all dummy variables (e.g., ban indicators, individual characteristics) constant at zero. We compute these values for the regressions with binary ban dummies but not the ban encounter probability. In a separate regression that includes only the ban encounter probability but not the ban dummy variables, we estimate the marginal effect of a 1 percent increase in the probability of encountering a ban. In each case, we compute the marginal effect at the mean for the remaining continuous variables (e.g., cigarette price) and at zero for the remaining dummy variables (e.g., individual characteristics).

Our model also attempts to account for potential endogeneity among the tobacco policy variables—bans, taxes, and state tobacco control funding. The relationship between tobacco control policy and cigarette consumption may not be completely causal: One major issue in the literature on smoking is that the possibility of tobacco control policies reflecting public sentiment toward smoking is largely unaddressed. Indeed, Hamilton, Biener, and Brennan (2008) find that local tobacco control regulations are correlated with individual perceptions of descriptive and injunctive norms, supporting the notion of a social multiplier effect (Cutler and Glaeser, 2010). It follows, then, that a high level of public distaste for smoking may increase the perceived need for and adoption of tobacco control policies (Hersch, Del Rossi, and Viscusi, 2004). Consequently, regulations may increase the public demand for further anti-smoking regulation. In fact, evidence suggests that states adopting 100-percent smoke-free bans are likely to have lower smoking rates and more tobacco control policies (Dunham and Marlow, 2000, and Boyes and Marlow, 1996). Hence, a smoking ban may follow rather than dictate changes in smoking behaviors and norms. Despite this evidence, Chaloupka (1992) and Wasserman et al. (1991) argue that when individual-level data are used to estimate cigarette demand, endogeneity is not a problem because the presence of clean indoor air laws is more closely related to average state-level cigarette consumption. In other words, they argue that a single individual's decision to smoke will not factor into legislators' decisions to enact more stringent tobacco control policies, but the decisions of a group of individuals will.

In light of these arguments, we tackle endogeneity issues in two ways: First, following Chaloupka (1992) and Picone, Sloan, and Trogdon, (2004), we use 1-quarter-lagged ban variables and 1-year-lagged state funding variables. However, we do not lag the cigarette price variable or the ban probability in the interaction term because we assume that individuals respond to these factors immediately. Second, following Farrelly et al. (2001), we control for time- and state-specific fixed effects. By controlling for cultural/regional and temporal variation in smoking attitudes, we take into account the differences in state smoking rates, which arguably influence legislators' decisions to enact bans in the first place.

DATA

To estimate the causal effects of clean indoor air laws in workplaces, bars, and restaurants on smoking behavior, one would ideally have panel data on individuals, their smoking habits,

their level of addiction, the factors that influence their smoking decisions, and how often they encounter smoking bans. Unfortunately, only cross-sectional data on individual smoking consumption exist, so an individual's response to smoking bans cannot be observed over time. In an attempt to circumvent this problem, this paper uses repeated cross-sectional data from the CDC's Behavioral Risk Factor Surveillance System survey (BRFSS).[2]

In addition to being conditioned on individual-level factors, we assume smoking behavior is driven by aggregate policy-level factors, such as the tax per pack of cigarettes, an anti-smoking "culture" inferred from tobacco control policies, and the presence of bans themselves.[3] Since the BRFSS data lack information on smoking policies within a municipality, county, or state, we merge the BRFSS data with 100-percent smoke-free workplace, bar, and restaurant ban enactment data, the annual average state-level price per pack of cigarettes (including taxes), and each state's average annual tobacco control spending per capita.[4] Also, because the BRFSS data are at the county level and the smoking ban data are available at the municipality level, we use municipality, county, and core based statistical area (CBSA) populations to calculate the probability of encountering a 100-percent smoke-free ban.[5]

Overall, 42 percent of respondents have smoked, 24 percent are current smokers, and 18 percent are former smokers (see Table 1). Of the current smokers (56 percent of those who have ever smoked), 57 percent have attempted to quit within the past year. Across counties that have enacted smoking bans, there are very few differences in demographic characteristics. The same applies to smoking behaviors: There is at most a 7 percent difference in smoking behaviors and demographic characteristics across individuals living in areas with and without bans.

As shown in Table 2, 46 percent of all individuals in the sample live in a county with a smoking ban; state-level smoking bans in restaurants are the most commonly encountered type of ban (32 percent of the sample); and county-level workplace, bar, and restaurant bans are the least common (1 percent, 0 percent, and 1 percent of the sample, respectively).[6] Although only 46 percent of the sample lives in a county with a smoking ban, 53 percent of the survey respondents live in a metropolitan area with a ban.[7] All respondents are most likely to encounter bans in restaurants and least likely to encounter bans in bars. For more information on the samples and data, see the data appendix and/or contact the authors.

Table 2 and Figure 2 indicate that over time, the presence of all three types of bans at the municipality, county, and state levels has increased dramatically. These increases were largely driven by the spread of state-level smoking bans rather than municipality- or county-level bans. For example, in 2001, 3 percent of BRFSS survey respondents encountered a state-level bar ban; but in 2009, 53 percent of respondents encountered such a ban. In contrast, in 2001, 4 percent of respondents encountered a municipality-level smoking ban in bars and 0 percent encountered one in their county. By 2009, those numbers rose to 9 percent and 1 percent, respectively. Figure 2 indicates that though the presence of these bans has spread, they have largely been clustered in the West and Northeast. As such, the bans are likely correlated with cultural and political factors.

RESULTS

Tables 3 through 5 present the estimated coefficients of smoking bans and tobacco policy on smoking initiation (Table 3), continuation (Table 4), and cessation (Table 5). In these tables,

Table 1

Summary Statistics of Select Variables

Variable	All	No Ban	Ban	Variable	All	No Ban	Ban
Has smoked	42	44	40	Female	60	60	61
	(49)	(50)	(49)		(49)	(49)	(49)
Current smoker	24	26	21	White	74	76	72
	(42)	(44)	(41)		(44)	(43)	(45)
Former smoker	18	18	19	Single	38	39	36
	(39)	(38)	(39)		(48)	(49)	(48)
Quit attempt	14	15	12	Parent	62	61	63
	(34)	(36)	(33)		(48)	(49)	(48)
Smoker*	56	60	53	Drinker	59	58	61
	(50)	(49)	(50)		(49)	(49)	(49)
Former smoker*	44	40	47	Employed	77	77	77
	(50)	(49)	(50)		(42)	(42)	(42)
Quit attempt**	57	56	59	Income <$25,000	15	16	14
	(49)	(50)	(49)		(36)	(37)	(34)
Age <25	18	17	19	Income <$50,000	20	23	18
	(38)	(37)	(39)		(40)	(42)	(38)
Age <30	12	13	11	Income <$75,000	36	38	34
	(32)	(35)	(31)		(48)	(48)	(47)
Age <35	13	14	13	Income >$75,000	29	23	34
	(34)	(34)	(33)		(45)	(42)	(47)
Age <40	17	17	16	Cigarette price + tax	4.42	4.31	4.51
	(38)	(37)	(37)	($, per pack)	(0.68)	(0.58)	(0.75)
Age <45	19	19	20	State funding ($, per capita)	2.74	2.81	2.68
	(39)	(39)	(40)		(2.73)	(2.64)	(2.80)
Age <50	21	20	21	Beer price ($, per 6-pack)	8.12	8.53	7.67
	(41)	(40)	(41)		(1.10)	(0.93)	(1.10)
HS non-graduate	07	07	07	Indoor workplace	38.26	38.09	39.32
	(26)	(26)	(25)		(4.82)	(4.60)	(4.78)
HS graduate	26	29	24	Restaurant	2.81	2.78	2.83
	(44)	(45)	(43)		(0.58)	(0.66)	(0.61)
Some college	28	30	27	Bar	0.67	0.73	0.62
	(45)	(46)	(45)		(0.51)	(0.58)	(0.42)
College graduate	38	34	41	Urban	93	91	95
	(49)	(47)	(49)		(25)	(29)	(22)

NOTE: All demographic variables are dummy variables. Standard deviations are listed in parentheses. Values are percents unless otherwise noted. The total number of observations is 965,359; of these 507,540 are within areas with bans. *Sample of respondents who have smoked; **sample of respondents who are current smokers.

Table 2

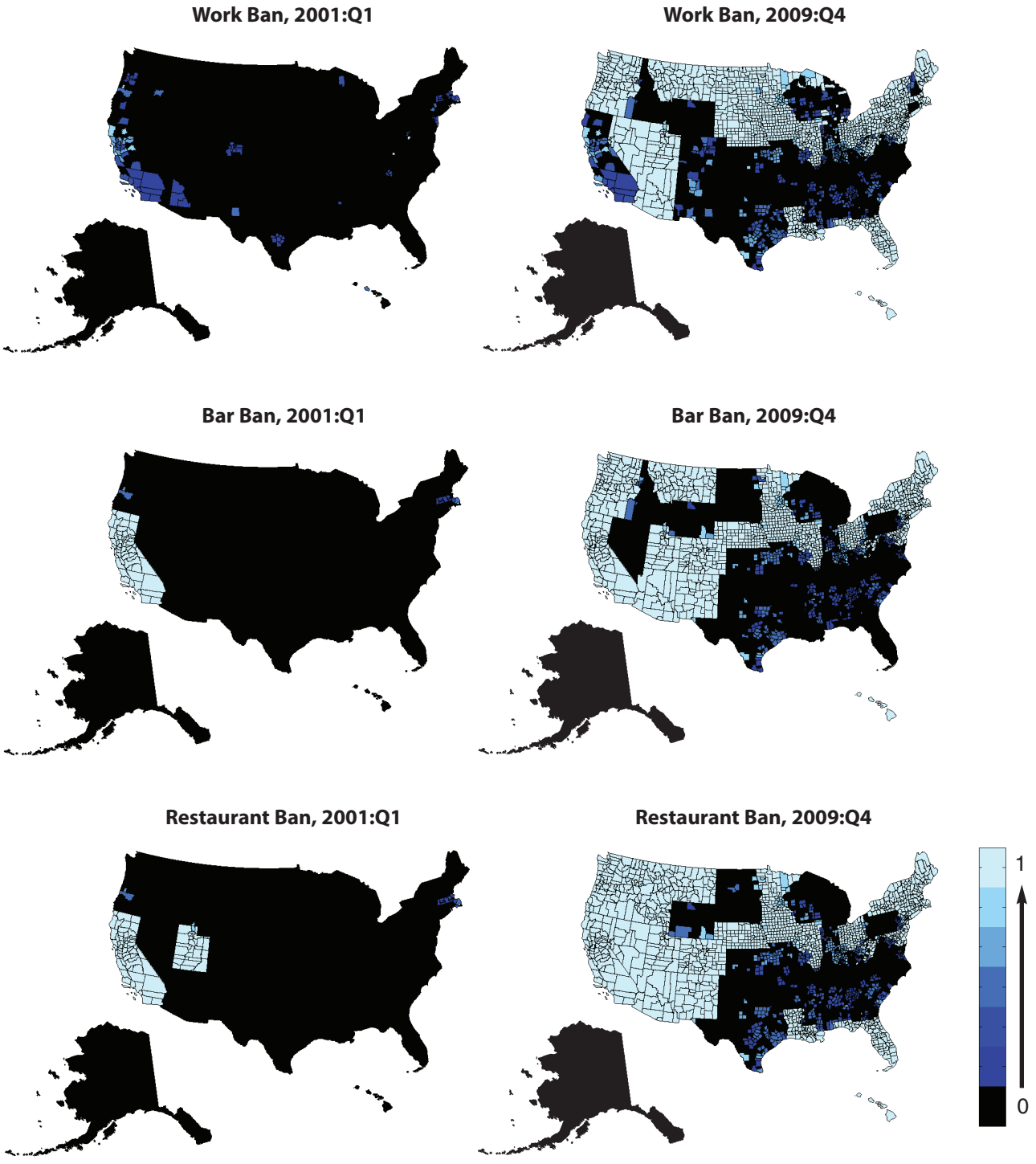
Ban Statistics

Type of ban	All	2001	2009
Municipality workplace ban	12	8	17
	(33)	(27)	(38)
County workplace ban	1	0	2
	(10)	(2)	(13)
State workplace ban	24	0	47
	(42)	(0)	(50)
Any workplace ban in CBSA	44	14	72
	(50)	(32)	(45)
Workplace ban probability	29	1	57
	(44)	(7)	(47)
Municipal bar ban	7	4	9
	(25)	(19)	(29)
County bar ban	0	0	1
	(6)	(0)	(11)
State bar ban	24	3	53
	(43)	(16)	(50)
Any bar ban in CBSA	36	7	69
	(48)	(27)	(46)
Bar ban probability	27	3	57
	(42)	(16)	(46)
Municipality restaurant ban	8	4	12
	(28)	(20)	(32)
County restaurant ban	1	0	1
	(09)	(01)	(11)
State restaurant ban	32	5	60
	(47)	(22)	(49)
Any restaurant ban in CBSA	45	11	79
	(50)	(31)	(41)
Restaurant ban probability	36	6	66
	(45)	(22)	(43)
Any ban in county	46	12	78
	(50)	(32)	(41)
Any ban in CBSA	53	15	83
	(50)	(36)	(37)
Observations	965,359	76,483	119,260

NOTE: All variables except probabilities are dummy variables. Standard deviations are listed in parentheses. Values are percents. Ban dummy variables refer to bans in counties. Ban probabilities use the probability of encountering a ban in a CBSA for urban residents and in a county for rural residents.

Figure 2

Smoking Ban Probabilities (2001:Q1–2009:Q4)



each column represents different specifications: Column 1 contains the results for the baseline regression, in which we explicitly control for each type of municipal-, county-, and state-level ban and the chance of encountering each of these bans. The remaining columns present results for various robustness checks. Column 2 contains the results for the probability of encountering a ban only. Column 3 controls for state-level bans and the probability of encountering any type of ban in an attempt to control the multicollinearity within the regression. Column 4 controls only for the type of ban encountered. Column 5 includes establishment shares (i.e., bars as a percentage of total establishments in a county) in the probability of encountering a ban.[8] Table 6 shows the estimated marginal effects for the specifications in columns 2 and 4 for each of the dependent variables. Because the results for the individual-level covariate, $\boldsymbol{Z}_i$, are robust to changing the specification of the ban variables, we present probit coefficients from the baseline regression in Table 7 and marginal effects from the fourth specification (i.e., column 4 in Tables 3 through 5) in Table 8.

Despite some statistically significant coefficients on the ban dummy variables, we find that the correlations between smoking bans and the smoking behaviors examined are not quantitatively significant. In other words, the bans do not generally correlate with fewer people starting to smoke or continuing to smoke. They also do not generally correlate with more people attempting to quit smoking. In the following section, we discuss each of the examined smoking behaviors separately.

Effects on Smoking Behaviors

Smoking Initiation. Table 3 contains the results for the probit regression with smoking initiation (whether a respondent has smoked 100 cigarettes in his or her lifetime) as the left-hand-side variable and various specifications of the vector of policy-level variables. The results in column 1 indicate that the presence of any indoor workplace, municipality bar, municipality restaurant, or state restaurant ban is not statistically significantly correlated with the number of respondents who have smoked in their lifetime. These results imply that the adoption of these types of smoking bans is independent of the smoking rates in a particular region and that individuals are no less likely to start smoking in areas where indoor workplace and restaurant smoking bans exist.

The presence of a county- or state-level bar ban, as well as the probability of encountering a smoking ban in a bar, is statistically significant from zero, suggesting that smoking initiation is negatively correlated with the presence of county- and state-level bar bans and, for those who drink, the presence of any bar ban. These coefficients are not only statistically significant, but also larger in magnitude than those of the other policy variables, though they are relatively small compared with those of the demographic variables. Further, only a small number of respondents encounter a county-level ban, making the correlations between initiation and county-level bar and restaurant bans possibly spurious. The marginal effects of these coefficients show that county-level and state-level bar bans are associated, respectively, with a 2.5 percent and a 1.9 percent decrease in the probability that an individual has smoked. The introduction of any smoking ban in bars is associated with up to a 1.3 percent decrease in smoking initiation among individuals who drink.

Table 3

Initiation Probit Results

	Baseline	Robustness checks			
Variable	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**
Municipality workplace ban	0.000	—	—	0.001	0.003
	(0.025)	—	—	(0.204)	(0.500)
County workplace ban	–0.001	—	—	0.000	0.005
	(0.040)	—	—	(0.014)	(0.276)
State workplace ban	0.003	—	0.004	0.007	0.013
	(0.398)	—	(0.417)	(0.883)	(1.265)
Probability of encountering workplace ban	0.003	0.004	0.002	—	—
	(0.386)	(0.641)	(0.354)	—	—
Probability of encountering workplace ban × Indoor workplace %	—	—	—	—	0.000
	—	—	—	—	(1.008)
Municipality bar ban	–0.003	—	—	–0.008	–0.009
	(0.282)	—	—	(0.634)	(0.742)
County bar ban	–0.064*	—	—	–0.066*	–0.068*
	(1.980)	—	—	(2.066)	(2.102)
State bar ban	–0.039**	—	–0.037**	–0.050**	–0.053**
	(3.832)	—	(3.604)	(5.230)	(5.160)
Probability of encountering bar ban	–0.024**	–0.033**	–0.026**	—	—
	(3.651)	(5.541)	(4.003)	—	—
Probability of encountering bar ban × Bar %	—	—	—	—	0.007
	—	—	—	—	(0.747)
Municipality restaurant ban	–0.015	—	—	–0.018	–0.018
	(1.305)	—	—	(1.617)	(1.595)
County restaurant ban	0.063**	—	—	0.055*	0.055*
	(2.677)	—	—	(2.460)	(2.312)
State restaurant ban	0.023	—	0.027*	0.012	0.011
	(1.724)	—	(2.119)	(1.189)	(0.893)
Probability of encountering restaurant ban	–0.011	–0.008	–0.013	—	—
	(1.101)	(1.331)	(1.461)	—	—
Probability of encountering restaurant ban × Restaurant %	—	—	—	—	0.000
	—	—	—	—	(0.124)
Cigarette price + tax (per pack)	0.017	0.008	0.015	0.016	0.016
	(0.746)	(0.351)	(0.665)	(0.698)	(0.692)
State tobacco control funding	0.004	0.004	0.004	0.005	0.005
	(1.351)	(1.332)	(1.259)	(1.516)	(1.468)
Beer price (per 6-pack)	–0.019	–0.019	–0.014	–0.017	–0.016
	(0.426)	(0.428)	(0.311)	(0.365)	(0.361)
% Correctly predicted	65.26	65.26	65.27	65.25	65.26

NOTE: The absolute values of *z*-statistics are listed in parentheses. * and ** indicate significance at the 5 percent and 1 percent levels, respectively; 965,359 observations.

Table 4

Continuation Probit Results

	Baseline	Robustness checks			
Variable	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**
Municipality workplace ban	–0.001	—	—	–0.006	0.005
	(0.075)	—	—	(0.594)	(0.461)
County workplace ban	–0.049	—	—	–0.066*	–0.038
	(1.715)	—	—	(2.324)	(1.306)
State workplace ban	0.003	—	0.005	–0.02	0.014
	(0.191)	—	(0.390)	(1.698)	(0.884)
Probability of encountering workplace ban	–0.037**	–0.036**	–0.038**	—	—
	(3.560)	(4.075)	(3.768)	—	—
Probability of encountering workplace ban × Indoor workplace %	—	—	—	—	–0.001**
	—	—	—	—	(3.768)
Municipality bar ban	–0.003	—	—	–0.016	–0.025
	(0.147)	—	—	(0.836)	(1.331)
County bar ban	–0.005	—	—	–0.029	–0.053
	(0.110)	—	—	(0.594)	(1.083)
State bar ban	0.008	—	0.012	–0.031*	–0.056**
	(0.524)	—	(0.737)	(2.059)	(3.447)
Probability of encountering bar ban	–0.072**	–0.067**	–0.071**	—	—
	(7.111)	(7.159)	(7.067)	—	—
Probability of encountering bar ban × Bar %	—	—	—	—	0.054
	—	—	—	—	(3.886)**
Municipality restaurant ban	–0.046*	—	—	–0.037*	–0.029
	(2.468)	—	—	(2.049)	(1.599)
County restaurant ban	–0.012	—	—	0.012	0.034
	(0.344)	—	—	(0.373)	(0.971)
State restaurant ban	–0.011	—	0.017	0.016	0.037
	(0.539)	—	(0.856)	(0.965)	(1.884)
Probability of encountering restaurant ban	0.032*	0.025*	0.006	—	—
	(2.132)	(2.506)	(0.418)	—	—
Probability of encountering restaurant ban × Restaurant %	—	—	—	—	–0.009
	—	—	—	—	(1.849)
Cigarette price + tax (per pack)	–0.168**	–0.164**	–0.166**	–0.169**	–0.169**
	(4.770)	(4.691)	(4.745)	(4.814)	(4.803)
State tobacco control funding	0.005	0.003	0.004	0.006	0.005
	(1.026)	(0.513)	(0.719)	(1.216)	(0.948)
Beer price (per 6-pack)	0.071	0.09	0.074	0.074	0.076
	(1.019)	(1.289)	(1.060)	(1.066)	(1.084)
% Correctly predicted	65.083	65.098	65.079	65.081	65.076

NOTE: The absolute values of *z*-statistics are listed in parentheses. * and ** indicate significance at the 5 percent and 1 percent levels, respectively; 404,861 observations.

Table 5

Cessation Probit Results

	Baseline	Robustness checks			
Variable	(1)	(2)	(3)	(4)	(5)
Municipality workplace ban	0.004	—	—	0.006	0.007
	(0.293)	—	—	(0.412)	(0.468)
County workplace ban	–0.048	—	—	–0.043	–0.042
	(1.318)	—	—	(1.208)	(1.120)
State workplace ban	–0.001	—	0.000	0.006	0.007
	(0.034)	—	(0.006)	(0.372)	(0.307)
Probability of encountering workplace ban	0.011	0.009	0.008	—	—
	(0.795)	(0.753)	(0.649)	—	—
Probability of encountering workplace ban × Indoor workplace %	—	—	—	—	0.000
	—	—	—	—	(0.262)
Municipality bar ban	0.046	—	—	0.049*	0.046
	(1.852)	—	—	(1.973)	(1.819)
County bar ban	0.032	—	—	0.038	0.028
	(0.528)	—	—	(0.622)	(0.461)
State bar ban	–0.026	—	–0.030	–0.018	–0.028
	(1.241)	—	(1.436)	(0.917)	(1.288)
Probability of encountering bar ban	0.015	0.010	0.018	—	—
	(1.091)	(0.787)	(1.313)	—	—
Probability of encountering bar ban × Bar %	—	—	—	—	0.021
	—	—	—	—	(1.148)
Municipality restaurant ban	–0.024	—	—	–0.026	–0.023
	(0.976)	—	—	(1.117)	(0.960)
County restaurant ban	0.015	—	—	0.008	0.018
	(0.337)	—	—	(0.185)	(0.408)
State restaurant ban	0.013	—	0.007	0.004	0.016
	(0.463)	—	(0.273)	(0.201)	(0.610)
Probability of encountering restaurant ban	–0.010	–0.011	–0.003	—	—
	(0.490)	(0.874)	(0.184)	—	—
Probability of encountering restaurant ban × Restaurant %	—	—	—	—	–0.005
	—	—	—	—	(0.734)
Cigarette price + tax (per pack)	0.153**	0.151**	0.158**	0.153**	0.151**
	(3.328)	(3.312)	(3.441)	(3.328)	(3.297)
State tobacco control funding	–0.019**	–0.018**	–0.018**	–0.019**	–0.019**
	(2.902)	(2.772)	(2.841)	(2.919)	(2.909)
Beer price (per 6-pack)	–0.177	–0.197*	–0.186*	–0.178	–0.176
	(1.943)	(2.166)	(2.043)	(1.949)	(1.926)
% Correctly predicted	58.99	58.96	58.97	58.98	58.98

NOTE: The absolute values of *z*-statistics are listed in parentheses. * and ** indicate significance at the 5 percent and 1 percent levels, respectively.

Table 6

Marginal Effects of Bans on Smoking Behavior

Variable	Initiation*		Continuation†		Cessation‡	
Municipality workplace ban	0.1	—	–0.2	—	0.2	—
County workplace ban	0.0	—	–2.6	—	–1.7	—
State workplace ban	0.3	—	–0.8	—	0.2	—
Probability of encountering a workplace ban	—	0.1	—	–1.4	—	0.3
Municipality bar ban	–0.3	—	–0.6	—	1.9	—
County bar ban	–2.5	—	–1.1	—	1.5	—
State bar ban	–1.9	—	–1.2	—	–0.7	—
Probability of encountering a bar ban	—	–1.3	—	–2.6	—	0.4
Municipality restaurant ban	–0.7	—	–1.5	—	–1.0	—
County restaurant ban	2.2	—	0.5	—	0.3	—
State restaurant ban	0.5	—	0.6	—	0.2	—
Probability of encountering a restaurant ban	—	–0.3	—	1.0	—	–0.4
Cigarette price + tax (per pack)	0.6	0.3	–6.6	–6.4	6.0	5.9
State tobacco control funding	0.2	0.2	0.2	0.1	–0.7	–0.7
Beer price (per 6-pack)	–0.6	–0.8	2.9	3.5	–7.0	–7.7

NOTE: Marginal effects are denoted in percent and were estimated at the mean of the continuous variables and at 0 for all other dummy variables using the specifications in columns 2 and 4 in Tables 3 through 5. (*The left-column values correspond to column 4 probit results and the right-column values correspond to column 2 probit results in Table 3. †The left-column values correspond to column 4 probit and the right-column values correspond to column 2 probit results in Table 4. ‡The left-column values correspond to column 4 probit and the right-column values correspond to column 2 probit results in Table 5.) Marginal effects for continuous variables represent the change in the probability associated with an infinitesimal change in the variable evaluated at the mean of the other variables; marginal effects for dummy variables report the change in the probability associated with a discrete change in the variable.

One interpretation of the results is that, in the absence of exposure to smoking in bars, individuals are more likely to begin smoking. Alternatively, government officials may be more likely to pass smoking bans in bars if there are lower smoking rates among their constituents (see Pakko, 2006, for an explanation). Given the relative magnitudes of these marginal effects and coefficients, the latter seems plausible for the state-level ban. Regardless, the marginal effects of instituting a smoking ban on smoking behavior are small compared with the effects of other individual-level characteristics associated with smoking initiation (see Table 8).

Smoking Continuation. Table 4 presents the results for smoking continuation. The correlation between continuation and smoking ban dummy variables is generally not statistically significant. In fact, only the municipality-level restaurant smoking bans are statistically significant, suggesting that restaurant bans at the local level are either more likely to encourage successful quitting or are more likely to be passed because the area already has a high number of nonsmokers. The effect of bans on smoking behavior, though, is still small compared with the effect of cigarette prices and other demographic variables. For the mean individual in the sample, the effects of instituting a ban are small (approximately a 1.5 percent decrease in the likelihood of being a current smoker) compared with increases in cigarette prices (between a 6.4 and a 6.6 percent decrease).

Table 7

Probit Results for Controls

Variable	Initiation	Continuation	Cessation
Female	–0.071**	0.026**	0.057**
	(25.133)	(6.004)	(10.101)
Age ≥ 25 & < 30	–0.513**	0.373**	0.349**
	(99.320)	(45.662)	(35.285)
Age <35	–0.233**	0.267**	0.218**
	(47.700)	(35.916)	(22.333)
Age <40	–0.223**	0.219**	0.136**
	(48.259)	(31.025)	(14.344)
Age <45	–0.190**	0.197**	0.045**
	(42.889)	(29.353)	(5.027)
Age <50	–0.093**	0.115**	(0.002)
	(21.687)	(18.377)	(–0.224)
Single	0.103**	0.277**	–0.039**
	(32.181)	(58.111)	(6.442)
Parent	–0.042**	–0.101**	0.091**
	(13.999)	(22.202)	(15.618)
High school graduate	–0.237**	–0.197**	(0.017)
	(40.759)	(24.612)	(–1.92)
Some college	–0.419**	–0.366**	0.127**
	(71.189)	(44.763)	(13.796)
College graduate	–0.878	–0.706**	0.134**
	(144.280)**	(80.935)	(12.625)
Income < $50,000	–0.095**	–0.119**	–0.028**
	(20.397)	(17.342)	(3.504)
Income < $75,000	–0.236**	–0.297**	–0.052**
	(50.586)	(42.947)	(6.296)
Income ≥ $75,000	–0.388**	–0.499**	–0.057**
	(73.002)	(61.618)	(5.455)
Employed	–0.057**	–0.025**	–0.071**
	(14.583)	(4.131)	(9.603)
Drinker	0.363**	0.183**	–0.025**
	(108.682)	(35.374)	(3.79)
Survey year	–0.009**	–0.004**	0.009**
	(8.558)	(2.640)	(4.311)
Constant	18.125**	8.979**	–17.088**
	(8.694)	(2.796)	(4.167)
F-statistic: Race	18035.900**	808.510**	1201.907**
F-Statistic: State	3020.399**	1592.463**	232.856**

NOTE: The absolute values of *z*-statistics are listed in parentheses. * and ** indicate significance at the 5 percent and 1 percent levels, respectively.

Table 8

Marginal Effects of Controls on Smoking Behavior

Variable	Initiation	Continuation	Cessation
Female	–2.8	1.0	2.2
Age ≥ 25 & < 30	–18.6	14.0	13.2
Age <35	–8.8	10.2	8.4
Age<40	–8.5	8.5	5.3
Age<45	–7.3	7.6	1.8
Age<50	–3.6	4.5	0.1
Single	4.0	10.8	–1.5
Parent	–1.6	–4.0	3.6
High school graduate	–9.1	–7.8	0.7
Some college	–15.8	–14.4	5.0
College graduate	–32.3	–27.6	5.2
Income < $50,000	–3.7	–4.7	–1.1
Income < $75,000	–9.1	–11.7	–2.0
Income ≥ $75,000	–14.7	–19.7	–2.2
Employed	–2.2	–1.4	–2.7
Drinker	13.7	6.5	–0.8
Survey year	–0.4	–0.2	0.3

NOTE: Marginal effects are denoted in percent and were estimated at the mean of the continuous variables and at 0 for all other dummy variables using the specifications in columns 2 and 4 in Tables 3 through 5. Marginal effects for continuous variables represent the change in the probability associated with an infinitesimal change in the variable evaluated at the mean of the other variables; marginal effects for dummy variables report the change in the probability associated with a discrete change in the variable.

Although the coefficients on the smoking ban dummy variables are statistically insignificant, those for the probabilities of encountering a bar ban are significant at the 5-percent or 1-percent level. Increasing the probability of encountering a bar ban has the largest effect of any ban, but it is still small compared with the effect of increasing cigarette prices. The potential effects associated with an increase in the probability of encountering a ban in the workplace (1.4 percent decrease) are also small. Unfortunately, these effects may be biased: The positive and significant coefficient on the probability of encountering a restaurant ban indicates there are more smokers in areas with restaurant bans. Despite this potential bias, price controls have larger and generally more statistically significant correlations with changes in smoking behavior than non-price controls.

Smoking Cessation. The final behavior examined—whether a current smoker has attempted to quit in the past year—indicates whether bans encourage people to stop smoking. Living in an area with any type of smoking ban is not correlated with an increased likelihood of cessation. Thus, enacting smoking prohibitions in indoor workplaces, bars, and restaurants does not appear to increase the likelihood that a current smoker will attempt to quit.

In contrast, a 1 percent increase in the price of a pack of cigarettes is associated with approximately a 6 percent increase in the likelihood that a current smoker has attempted to quit in the

past year. It is also worth noting that cessation is the only dependent variable for which state tobacco control funding is negative and statistically significant. It is possible either that states with fewer people attempting to quit smoking spend more on tobacco control or that policymakers are more likely to use more aggressive legislation (i.e., taxes and introduction of cessation programs rather than bans) to encourage smokers to quit.

Robustness of Findings

The remaining columns of Tables 3 through 5 check the robustness of our findings. These specifications exclude (some of) the ban dummy variables (columns 2 and 3), exclude the chance of encountering a ban (column 4), and scale the chance of encountering a smoking ban by the establishment shares for that particular type of ban (column 5). Regardless of specification, the results are largely consistent with those of the baseline regression for each dependent variable. Certain ban dummy variables do change statistical significance when the probabilities of encountering a ban are excluded (column 4).[9] This change suggests that some bans do have a statistically significant, albeit economically small, effect on some smoking behavior.

Factoring establishment shares into the probability of encountering a ban dramatically changes the magnitudes of the estimated coefficients on these probabilities. For example, the coefficient on the probability of encountering a workplace ban in column 5 of Table 4 is much closer to zero when controlling for the share of indoor workplaces. In other cases, scaling the probability of encountering a smoking ban by establishment share negates its statistical insignificance. To illustrate, the correlation between encountering a restaurant ban and smoking continuation (Table 4, column 5) has a different sign, but becomes statistically insignificant.

Controlling for establishments in the probability of encountering a smoking ban in a bar changes the sign of statistically significant coefficients. The change in sign indicates that areas with more bars are more likely to have higher smoking rates. This finding implies alcohol and cigarette consumption are complements. It follows, then, that areas with more bars may be less likely to enact smoking bans in bars because of the economic consequences for the bar industry. In fact, the counties and metropolitan areas in our data with the highest number of bars are those without bar bans. Since smoking restrictions in bars may be enacted in areas where they are naturally less likely to be encountered, their efficacy may be limited because they are easily avoidable.

CONCLUSION

We find that 100-percent smoke-free bans in indoor workplaces, bars, and restaurants are not typically correlated with smoking behavior: The effects of bans on the smoking behavior of individuals most likely to encounter bans are generally small or statistically insignificant. Because the data do not track the same individuals over time, we cannot observe changes in smoking activity. Thus, we do not test whether these effects are causal and cannot conclude that enacting a smoking ban has no effect on smoking behavior.

Several factors may explain the lack of an observed correlation between bans and smoking behavior even if bans do work. First, bans may change smoking behavior slowly, with effects seen only years after their enactment and possibly after the end of our data sample. Second,

bans may be endogenous—more prevalent in areas with initially higher smoking rates—and only equalize smoking rates across areas. However, a smoker is no more likely to have tried to quit in areas with smoking bans than in areas without smoking bans, providing some evidence against this form of endogeneity.

It is also possible that the results do indicate that bans are ineffective in changing smoking behavior. Smokers may have simply changed *where* they smoke instead of changing *how much* they smoke. For example, they may not consider smoking outside a bar or restaurant as an inconvenience. They may also spend less time at bars and restaurants and more time at home where they can smoke freely (Adda and Cornaglia, 2010). They may even be more willing to travel farther to areas without bans to go to bars and restaurants (Adams and Cotti, 2008). Thus, enacting a smoking ban may not increase the opportunity cost of smoking enough to significantly deter smokers from smoking.

Nonetheless, the results of this paper imply that increasing cigarette taxes may be more effective in changing smoking behavior than implementing a ban. In the majority of the estimates, the magnitude of an increase in cigarette prices is larger and of greater statistical significance than any of the magnitudes for an individual ban or the aggregate effect of all three types of bans. Hence, increasing taxes appears to be more effective in reducing the number of smokers. This finding is especially true in analyses of current smokers and their attempts to quit smoking: In all models of smoking cessation attempts, the ban variables are neither statistically nor economically significant, but the price variables are.

Although the correlations between bans and being a current smoker tend to be small relative to changes in price controls, smoking bans may still have health benefits by limiting individuals' exposure to secondhand smoke. In fact, previous studies find that smoking bans do not have significant effects on the smoker but do decrease the amount of secondhand smoke in workplaces, bars, and restaurants (Carpenter, 2009, and Carpenter, Postolek, and Warman, 2011) and the number of smoking-related hospital admissions (Juster et al., 2007).

A final consideration must be the economic effect of the bans on businesses. Pakko (2006) argues that these effects vary depending on an establishment's clientele and marketing, especially in the entertainment and hospitality sectors. If imposing a ban has little correlation with or little effect on smoker behavior, it is important to consider the outcomes for all affected parties—smokers, nonsmokers, and business owners who are forced to comply with such regulations. Only after quantifying these factors can we determine whether smoking bans increase social welfare.

NOTES

1 One feature of the probit is that it is robust to the presence of time-invariant variables (Gallet, Hoover, and Lee, 2006). This proves useful here as a number of our regressors vary across space but not across time.

2 Centers for Disease Control and Prevention (CDC). *Behavioral Risk Factor Surveillance System Survey Data*. Atlanta, Georgia: U.S. Department of Health and Human Services, 2001-09.

3 See Siegel and Biener, 2000; Liu and Tan, 2009; Marlow, 2007.

4 Ban data are from Americans Nonsmoker's Rights Foundation. Chronological Table of U.S. Population Protected by 100-percent Smoke-Free State or Local Laws (data file), 2010; www.no-smoke.org/pdf/EffectivePopulationList.pdf. Cigarette price data are from (i) Orzechowski, William and Walker, Robert. *The Tax Burden on Tobacco: Historical*

Compilation. Volume 44. Arlington, VA; (ii) Council for Community and Economic Research. *ACCRA Cost of Living Index*. Arlington, VA: Council for Community and Economic Research, 2010. State tobacco control funding data are from (i) ImpacTeen State Level Tobacco Control Policy and Prevalence Database. Tobacco Control Policy and Prevalence Data: 1991-2008, http://www.impacteen.org/tobaccodata.htm; (ii) CDC. State Tobacco Activities Tracking and Evaluation (STATE) System, http://apps.nccd.cdc.gov/statesystem/DetailedReport/DetailedReports.aspx; and (iii) Council for Community and Economic Research. *ACCRA Cost of Living Index*. Arlington, VA: Council for Community and Economic Research, 2010.

[5] Data are from (i) U.S. Census Bureau. Population Estimates—All States, All Geography, 2009, www.census.gov/popest/data/cities/totals/2009/files/SUB-EST2009_ALL.csv; (ii) U.S. Census Bureau. Annual Estimates of the Population of Combined Statistical Areas: April 1, 2000 to July 1, 2009, www.census.gov/popest/data/metro/totals/2009/tables/CBSA-EST2009-02.csv; (iii) U.S. Census Bureau. Metropolitan and Micropolitan Statistical Areas and Components, December 2009, With Codes, 2009, www.census.gov/population/metro/files/lists/2009/List1.txt; and (iv) Missouri Census Data Center, http://mcdc.missouri.edu/.

[6] Of the total sample, 5 percent lives in a municipality or county without a smoking ban that is located in a CBSA with other municipalities or counties that do have smoking bans.

[7] Of urban respondents, 87 percent live in a CBSA with a ban.

[8] Establishment numbers are from the U.S. Census Bureau, County Business Patterns, 2001-2009, www.census.gov/econ/cbp/download/index.htm.

[9] Additional robustness checks examining various ban dummy variable and ban probability lags were estimated. The results of these estimates were consistent with those reported in this paper.

REFERENCES

Adams, Scott J. and Cotti, Chad. "Drunk Driving after the Passage of Smoking Bans in Bars." *Journal of Public Economics*, June 2008, *92*(5-6), pp. 1288-305.

Adda, Jérôme and Cornaglia, Francesca. "The Effect of Bans and Taxes on Passive Smoking." *American Economic Journal: Applied Economics*, January 2010, *2*(1), pp. 1-32.

Bask, Mikael and Melkersson, Maria. "Rationally Addicted to Drinking and Smoking?" *Applied Economics*, 2004, *36*(4), pp. 373-81.

Boyes, William J. and Marlow, Michael L. "The Public Demand for Smoking Bans." *Public Choice*, July 1996, *88*(1-2), pp. 57-67.

Brownson, Ross C.; Hopkins, David P. and Wakefield, Melanie A. "Effects of Smoking Restrictions in the Workplace." *Annual Review of Public Health*, May 2002, *23*, pp. 333-48.

Carpenter, Christopher. S. "The Effects of Local Workplace Smoking Laws on Smoking Restrictions and Exposure to Smoke at Work." *Journal of Human Resources*, Fall 2009, *44*(4), pp. 1023-046.

Carpenter, Christopher S.; Postolek, Sabina and Warman, Casey R. "Public-Place Smoking Laws and Exposure to Environmental Tobacco Smoke (ETS)." *American Economic Journal: Economic Policy*, August 2011, *3*(3), pp. 35-61.

Centers for Disease Control and Prevention. "State Smoke-Free Laws for Worksites, Restaurants, and Bars—United States, 2000-2010." *Morbidity and Mortality Weekly Report*, April 22, 2011, *60*(15), pp. 472-75.

Chaloupka, Frank J. "Clean Indoor Air Laws, Addiction and Cigarette Smoking." *Applied Economics*, 1992, *24*(2), pp. 193-205.

Chaloupka, Frank. J. and Saffer, Henry. "Clean Indoor Air Laws and the Demand for Cigarettes." *Contemporary Economic Policy*, 1992, *10*(2), pp. 72-83.

Cheng, Kai-Wen and Kenkel, Donald S. "U.S. Cigarette Demand: 1944-2004." *B.E. Journal of Economic Analysis and Policy*, January 2010, *10*(1), Article 78.

Cutler, David M. and Glaeser, Edward L. "Social Interactions and Smoking," in David A Wise, ed., *Research Findings in the Economics of Aging*. Chicago: University of Chicago Press, 2010, pp. 123-41.

DeCicca, Philip; Kenkel, Donald and Mathios, Alan. "Cigarette Taxes and the Transition from Youth to Adult Smoking: Smoking Initiation, Cessation, and Participation." *Journal of Health Economics*, July 2008a, *27*(4), pp. 904-17.

DeCicca, Philip; Kenkel, Donald; Mathios, Alan; Shin, Yoon-Jeong and Lim, Jae-Young. "Youth Smoking, Cigarette Prices, and Anti-Smoking Sentiment." *Health Economics*, 2008b, *27*(4), pp. 904-17.

Dedobbeleer, Nicole; Bèland, François; Contandriopoulos, André-Pierre and Adrian, Manuella. "Gender and the Social Context of Smoking Behaviour." *Social Science and Medicine*, January 2004, *58*(1), pp. 1-12.

DiFranza, Joseph R. and Guerrera, Mary P. "Alcoholism and Smoking." *Journal of Studies on Alcohol*, March 1990, *51*(2), pp. 130-35.

Dodgen, Charles E. *Nicotine Dependence: Understanding and Applying the Most Effective Treatment Interventions*. Washington, DC: American Psychological Association, 2005.

Dunham, John and Marlow, Michael L. "Smoking Laws and Their Differential Effects on Restaurants, Bars, and Taverns." *Contemporary Economic Policy*, July 2000, *18*(3), pp. 326-33.

Farrelly, Matthew C.; Evans, William N. and Sfekas, Andrew E.S. "The Impact of Workplace Smoking Bans: Results from a National Survey." *Tobacco Control*, September 1999, *8*(3), pp. 272-77.

Farrelly, Matthew C.; Bray, Jeremy W.; Pechacek, Terry and Woollery, Trevor. "Response by Adults to Increases in Cigarette Prices by Sociodemographic Characteristics." *Southern Economic Journal*, July 2001, *68*(1), pp. 156-65.

Gallet, Craig S.; Hoover, Gary A. and Lee, Junsoo. "Putting Out Fires: An Examination of the Determinants of State Clean Indoor-Air Laws." *Southern Economic Journal*, July 2006, *73*(1), pp. 112-24.

Hamilton, William L.; Biener, Lois and Brennan, Robert T. "Do Local Tobacco Regulations Influence Perceived Smoking Norms? Evidence from Adult and Youth Surveys in Massachusetts." *Health Education Research*, August 2008, *23*(4), pp. 709-22.

Harris, Jeffrey E. and Chan, Sandra W. "The Continuum-of-Addiction: Cigarette Smoking in Relation to Price among Americans Aged 15-29." *Health Economics*, 1999, *8*(1), pp. 81-86.

Hersch, Joni; Del Rossi, Alison F. and Viscusi, W. Kip. "Voter Preferences and State Regulation of Smoking." *Economic Inquiry*, July 2004, *42*(3), pp. 455-68.

Irvine, Ian J. and Nguyen, Hai V. "Toxic Choices: The Theory and Impact of Smoking Bans." *Forum for Health Economics & Policy*, 2011, *14*(2), Article 6.

Juster, Harlan R.; Loomis, Brett R.; Hinman, Theresa M.; Farrelly, Matthew C.; Hyland, Andrew; Bauer, Ursula E. and Birkhead, Guthrie S. "Declines in Hospital Admissions for Acute Myocardial Infarction in New York State after Implementation of a Comprehensive Smoking Ban." *American Journal of Public Health*, November 2007, *97*(11), pp. 2035-039.

Kim, Sei-Hill and Shanahan, James. "Stigmatizing Smokers: Public Sentiment Toward Cigarette Smoking and Its Relationship to Smoking Behaviors." *Journal of Health Communication*, July-August 2003, *8*(4), pp. 343-67.

Knudsen, Hannah K.; Boyd, Sara E. and Studts, Jamie L. "Substance Abuse Treatment Counselors and Tobacco Use: A Comparison of Comprehensive and Indoor-Only Workplace Smoking Bans." *Nicotine and Tobacco Research*, November 2010, *12*(11), pp. 1151-155.

Liu, Hong and Tan, Wei. "The Effect of Anti-Smoking Media Campaign on Smoking Behavior: The California Experience." *Annals of Economics and Finance*, May 2009, *10*(1), pp. 29-47.

Marlow, Michael L. "Do Tobacco-Control Programs Lower Tobacco Consumption? Evidence from California." *Public Finance Review*, 2007, *35*(6), pp. 689-709.

Pakko, Michael R. "On the Economic Analysis of Smoking Bans." Federal Reserve Bank of St. Louis *Regional Economic Development*, 2006, *2*(2), pp. 115-30; http://research.stlouisfed.org/publications/red/2006/02/Pakko.pdf.

Pakko, Michael R. "Clearing the Haze? New Evidence on the Economic Impact of Smoking Bans." Federal Reserve Bank of St. Louis *Regional Economist*, January 2008, pp. 10-11; www.stlouisfed.org/publications/pub_assets/pdf/re/2008/a/smoking-ban.pdf.

Picone, Gabriel A.; Sloan, Frank A. and Trogdon, Justin G. "The Effect of the Tobacco Settlement and Smoking Bans on Alcohol Consumption." *Health Economics*, October 2004, *13*(10), pp. 1063-080.

Ross, Hana and Chaloupka, F.J. "The Effect of Public Policies and Prices on Youth Smoking." *Southern Economic Journal*, April 2004, *70*(4), pp. 796-815.

Scollo, Michelle and Lal, Anita. "Summary of Studies Assessing the Economic Impact of Smoke-Free Policies in the Hospitality Industry." VicHealth Centre for Tobacco Control, Melbourne, Australia, February 2008; www.vctc.org.au/tc-res/Hospitalitysummary.pdf.

Siegel, Michael and Biener, Lois. "The Impact of an Antismoking Media Campaign on Progression to Established Smoking: Results of a Longitudinal Youth Study." *American Journal of Public Health*, March 2000, *90*(3), pp. 380-86.

Singleton, Perry. "Public Sentiment and Tobacco Control Policy." Syracuse University Center for Policy Research Working Paper No. 106, May 1, 2008.

Sung, Hai-Yen; Hu, Teh-Wei and Keeler, Theodore E. "Cigarette Taxation and Demand: An Empirical Model." *Contemporary Economic Policy*, July 1994, *12*(3), pp. 91-100.

Wasserman, Jeffrey; Manning, Willard G.; Newhouse, Joseph P. and Winkler, John D. "The Effects of Excise Taxes and Regulations on Cigarette Smoking." *Journal of Health Economics*, May 1991, *10*(1), pp. 43-64.

Yurekli, Ayda A. and Zhang, Ping. "The Impact of Clean Indoor-Air Laws and Cigarette Smuggling on Demand for Cigarettes: An Empirical Model." *Health Economics*, March 2000, *9*(2), pp. 159-70.

DATA APPENDIX

Individual-Level Data

The BRFSS, conducted by the CDC, provides all of the individual-level data on smoking and demographics for the sample of 965,359 individuals 18 to 50 years of age who were interviewed between January 2, 2001, and December 31, 2009. The appropriate variables were taken and coded as dummy variables.

Ban Data

We merged the BRFSS data by interview date and county code with the 100-percent smoke-free workplace, bar, and restaurant ban enactment data from the Americans for Nonsmokers' Rights (ANR). The ANR data were presented as simply the date on which a ban in a location (municipality, county, or state) went into effect. We manually geocoded county- and state-level bans, while we conducted a number of string-to-string merges with Census data to geocode the municipality-level bans. When a less stringent ban was passed after a more stringent ban (e.g., a municipality codified the more stringent ban in its own ordinance), we used the more stringent ban date. Our construction of the smoking ban variables did not take into account bans that had been passed and then repealed, as they were not included in the ANR data.

Ban Probability Data

We calculated the ban probabilities for urban residents by determining the portion of a CBSA population living in an area with a ban using annual place, county subdivision, county, state, and CBSA population data from the Census. We calculated ban probabilities for rural residents by determining the proportion of a county's population living in an area with a ban using annual place, county subdivision, and county population data from the Census. These probabilities were calculated for each of the three types of bans. In other words, the probabilities for a

workplace ban, bar ban, and restaurant ban may not be the same for an individual respondent. Instead, they reflect the probability of encountering each ban on its own. We then multiplied the workplace ban probabilities by an indicator (0, 1) for whether an individual is employed and multiplied the bar ban probabilities by an indicator (0,1) for whether an individual drinks.

Cigarette Price and State Tobacco Control Funding Data

The cigarette price and state tobacco control variables are annual, state-level variables. These nominal variables were adjusted using annual consumer price index data and again using quarterly values of the average ACCRA Cost of Living Index composite index for each state, as the number participating urban areas in each state in each quarter varied. In the end, these price variables control for temporal and geographic changes in the cost of living. They were matched to BRFSS respondents based on state Federal Information Processing Standard (FIPS) codes.

Establishment Data

The establishment data in the robustness checks are from the Census Bureau's County Business Patterns. Specifically, we used the total number of restaurants and bars in each county. To determine the total number of indoor workplace establishments, we took the sum of establishments in information services, finance, professional services, management, administrative services, healthcare, and manufacturing in each county. We divided the total number of indoor workplaces, restaurants, and bars by the total number of establishments within a county to obtain the establishment percentages.

Close

Michael T. Owyang

Research officer and economist, Federal Reserve Bank of St. Louis

http://research.stlouisfed.org/econ/owyang/

Research Focus

Mike Owyang's main areas of research are in Bayesian econometrics, time-series econometrics, and forecasting.

E. Katarina Vermann

Research associate, Federal Reserve Bank of St. Louis

Research Focus

Kate Vermann currently assists economists Mike Owyang and Subhayu Bandyopadhyay with their research. Her research interests also include labor, health, and urban economics with a focus on public policy.

The Extent and Impact of Outsourcing: Evidence from Germany

Craig Aubuchon, Subhayu Bandyopadhyay, and Sumon Kumar Bhaumik

The authors use data from several sources, including plant-level data from the manufacturing sector in Germany, to expand the literature on outsourcing. They find that, in Germany, the extent of outsourcing among manufacturing industries is higher than among service industries and that the outsourcing intensity of these industries did not change much between 1995 and 2005. They also find a *statistically* significantly positive impact of industry-level outsourcing intensity on German plant-level labor productivity for both 2000 and 2005. The estimated *economic* impact of outsourcing on plant-level productivity is also fairly significant. (JEL F16, D24)

Federal Reserve Bank of St. Louis *Review*, July/August 2012, *94*(4), pp. 287-304.

This paper incorporates plant-level data from the manufacturing sector in Germany to expand the literature on the impact of outsourcing on firm-level productivity. The 2009 Capgemini Executive Outsourcing Survey (Wilmot, 2009) indicates that nearly three-fourths of the (surveyed) executives believe that outsourcing enables firms to survive in today's global economy. They argue that outsourcing makes firms agile and flexible (60 percent), thereby making them better capable of facing competition, and that the money saved from outsourcing can facilitate growth (70 percent). However, in an era of high unemployment, criticism of outsourcing in the developed world is on the rise; and such criticism has found some support from academic research. Keuschnigg and Ribi (2009) demonstrated that outsourcing increases both unemployment and the labor income risk of unskilled workers in the home country. In addition, Zhang (2011) argued that even if outsourcing increases employment in the aggregate, it may cause net welfare loss through resource misallocation. Such findings have resulted in a wide range of propositions to reduce outsourcing, either by disincentivizing

Craig Aubuchon is a former research associate at the Federal Reserve Bank of St. Louis and a recent graduate of the Indiana University School of Public and Environmental Affairs. Subhayu Bandyopadhyay is a research officer and economist at the Federal Reserve Bank of St. Louis. Sumon Kumar Bhaumik is a reader in the Economics and Strategy Group at Aston Business School, Aston University, Birmingham, United Kingdom, and a research fellow at the William Davidson Institute at the University of Michigan, Ann Arbor, Michigan, and IZA (Institute for the Study of Labor) in Bonn, Germany. The authors thank the Institute for Employment Research (IAB) at Nuremberg, Germany, for providing the data and facilitating the empirical estimation and thank Lowell Rickets for excellent research assistance. They also thank Daniela Hochfellner and Peter Jacobebbinghaus of IAB for their continual support through the duration of the research and Gyde Neumann of Germany's Monopolkomission for providing the data on industry-level competition.

Table 1

Review of Literature on Impact of Outsourcing

Author	Country (year)	Industry	Impact of outsourcing on performance
Amiti and Wei (2006)	U.S. (1992-2000)	Manufacturing	Both servicing and materials outsourcing had a significant impact on productivity growth in the U.S., but the impact of servicing outsourcing was much greater than the impact of materials outsourcing and accounted for 10 percent of the growth in labor productivity.
Bachmann and Braun (2011)	Germany (1991-2000)	Manufacturing and services sectors	Overall, outsourcing increases job stability, much more so in the services sector than in the manufacturing sector. However, the impact of outsourcing varies by skill level of workers, with medium-skilled and older workers at higher risk of transitioning to non-employment.
Criscuolo and Leaver (2005)	U.K. (2000-03)	Manufacturing and services sectors	Firms that outsource are larger and more capital intensive, are bigger users of information and communications technology (ICT) capital, and have more international links than firms that do not outsource. The impact of outsourcing on productivity is positive but not large; a 10 percent increase in outsourcing increases total factor productivity by 0.37 percent. The effect of offshoring is caused largely by firms that are domestic and not engaged globally.
Daveri and Jona-Lasinio (2008)	Italy (1995-2003)	Selected manufacturing	Offshoring within the same industry is beneficial for productivity growth, but there is no observable benefit from offshoring of services. The positive effect of offshoring on productivity is not robust to the choice of outsourcing measure; it disappears when the FH measure (described in Table 2) is used instead of the input-output-based measure.
Egger and Egger (2006)	EU12 (1993-97)	Manufacturing	International outsourcing has a negative marginal impact on value added per low-skilled worker in the short run but a positive marginal impact in the longer run.
Girma and Görg (2004)	United Kingdom (1980-92)	Selected manufacturing	Outsourcing may be driven by the objective to reduce cost, and foreign firms are more likely to outsource than domestic firms. Outsourcing is associated with growth of both labor productivity and total factor productivity at the firm level, but foreign firms are more likely to benefit than domestic firms.
Görg and Hanley (2004)	Republic of Ireland (1990-95)	Electronics	Outsourcing can improve profitability of firms that are substantially larger than the average firm size, but there is no evidence of benefit for significantly smaller firms.
Görg and Hanley (2005)	Republic of Ireland (1990-95)	Electronics	Outsourcing of materials can generate significant productivity gains, but such gains only accrue to firms with low export intensity.

it by using an appropriate tax policy or by directly imposing a cap on the proportion of jobs that can be sent abroad to offshore firms.

The economic and political concerns about unemployment and income fragility must be balanced against the need to ensure productivity growth. The deep post-2008 financial and economic crisis may have permanently reduced the production capacity of industrialized countries by as much as 4 percent (Directorate-General for Economic and Financial Affairs, 2009, and Furceri and Mourougane, 2009), such that a rapid rise in productivity growth might be the only

Table 1, cont'd

Review of Literature on Impact of Outsourcing

Author	Country (year)	Industry	Impact of outsourcing on performance
Görg, Hanley, and Strobl (2008)	Republic of Ireland (1990-98)	Manufacturing	International services outsourcing has a significant positive effect on productivity, but (both domestic and foreign-owned) exporters are likely to gain, with no evidence of productivity gain for non-exporters.
Gorzig and Stephan (2002)	Germany (1992-2000)	Manufacturing	Both materials and services outsourcing have a positive impact on return per employee. However, the impact on profitability is asymmetric; materials outsourcing has a positive impact on profitability, while services outsourcing has a negative impact.
Hijzen, Inui, and Todo (2010)	Japan (1994-2000)	Manufacturing	Outsourcing to foreign affiliates increases a firm's productivity, but outsourcing to unaffiliated foreign firms does not have such an effect. Indeed, outsourcing to unaffiliated foreign affiliates has a negative impact on firms that are not multinationals and those that do not export, even though the impact on multinationals and exporting firms is non-negative.
Kurz (2006)	U.S. (1987-96)	Manufacturing	Outsourcing firms are larger, more capital intensive, and more productive. Outsourcing itself has a positive impact on firm productivity but not on plant-level productivity.
Moser, Urban, and Weder di Mauro (2009)	Germany (1998-2004)	All sectors (manufacturing treated separately)	Offshoring can reduce employment if it leads to downsizing of firms. But the lower cost and greater competitiveness on account of offshoring can lead to firm growth. Overall, increase in the foreign intermediate input share in total inputs has a significant positive impact on employment.
Olsen (2006)	Meta-analysis		As such, there is no clear pattern as to how offshore outsourcing affects productivity, and the likelihood or extent of gains depends on firm-level and industry-level characteristics. There is some evidence to suggest, however, that firms are more likely to benefit from outsourcing if they are already globally engaged.
Tomiura (2007)	Japan (1998)	Manufacturing	Firms with richer human skills or experience with FDI are more likely to outsource. Further, firms are more likely to offshore their activities if they are more productive and if their products are labor intensive.
Wagner (2011)	Germany (2001-03)	Manufacturing	Firms that offshore are larger, more productive, and more export-oriented than their non-offshoring counterparts; i.e., better firms self-select to offshore. There is no evidence of causal effect of offshoring on employment.

way to ensure that income levels in these economies recover to a pre-crisis level in the foreseeable future (Bhaumik, 2011). At its heart, outsourcing involves firms specializing in activities in which they have core competence (or comparative advantage) and interfirm trade in goods and services made possible by the unbundling of the production process.[1] Hence, economic theory suggests that it should have a positive impact on firm-level productivity.[2]

However, the evidence in the recent literature measuring the impact of outsourcing on productivity is somewhat mixed (Olsen, 2006). For example, Girma and Görg (2004) find that out-

sourcing in the United Kingdom, which was at least in part a cost-reducing strategy, raised productivity for some domestic manufacturing industries, especially for exporters. The greater impact of outsourcing on the productivity of exporters is also confirmed for the United States by Kurz (2006), for Ireland by Görg, Hanley, and Strobl (2008), and for Germany by Wagner (2011). But Criscuolo and Leaver (2005) find that in the United Kingdom most of the benefits of outsourcing accrue to firms that are not globally engaged. Similarly, Amiti and Wei (2006) find that (service) outsourcing, which does not contribute to job losses, contributes to higher total factor productivity (TFP). And Egger and Egger's (2006) study of 12 European Union countries suggests that the impact of outsourcing can change over time: It can have a negative impact on the real value added of workers in the short run, but this impact can be positive in the long run. Table 1 summarizes the key literature results on the impact of outsourcing on employment and firm performance.

It is not difficult to comprehend why the benefits of outsourcing may be limited. It is well understood that firm managers have their own vested interests that have little to do with firm performance, are boundedly rational, or can underestimate the magnitude of the cost of managing the outsourcing process and the contract with the vendors relative to benefits (on account of hubris). Hence, the realized net benefits of outsourcing may be significantly lower than the expected net benefits. Barthélemy (2001), for example, estimates that the cost of monitoring information technology vendors and the cost of bargaining and renegotiating contracts with them can be as high as 8 percent of the annual contract amount. Furthermore, it is difficult to estimate the costs of switching from in-house information technology activities to an external vendor and switching from one vendor to another. The actual cost of managing the overall outsourcing process can, therefore, be considerably higher. The marginal impact of outsourcing on firm performance might, therefore, be insignificant.

As mentioned earlier, we extend the literature on the impact of outsourcing on firm-level productivity using plant-level data from the German manufacturing sector. The choice of the country is deliberate; Germany's ability to benefit from outsourcing is not fully obvious (Farrell, 2004). We begin by examining the extent of outsourcing in German industries and the trend in outsourcing over time. We use a number of measures for 1995, 2000, and 2005 to estimate the extent of outsourcing in German industries over time. We compare and contrast the extent of outsourcing between the manufacturing and services sectors and also among the industries within each of these sectors. Thereafter, we examine the changes in the extent of outsourcing in these industries during the 1995-2000 and 2000-2005 periods. Next, we estimate the impact of industry-level outsourcing intensity on plant-level labor productivity for 2000 and 2005. We find that (i) the extent of outsourcing is higher among manufacturing industries in Germany than among service industries and (ii) the outsourcing intensity of these industries did not change much between 1995 and 2005. We also find a significantly positive and economically meaningful impact of industry-level outsourcing intensity on plant-level labor productivity in Germany's manufacturing sector[3] for both 2000 and 2005.

The rest of the paper is structured as follows: The next section discusses the empirical strategy and the data. In particular, we highlight the extent of (and trends in) outsourcing intensity among German industries during the 1995-2005 period. We then present the regression results on the impact of outsourcing on labor productivity. The final section presents our conclusion.

EMPIRICAL STRATEGY AND DATA

Empirical Strategy

We model (log) labor productivity (Y/L) as a function of (log) capital per employee (K/L), capital quality (KQ), labor skills (LS), and a number of other plant-level control variables (included in vector $\mathbf{Z}$). Finally, we add a measure of outsourcing (OSS), discussed below, to the regression specification. Our regression mode, therefore, is as follows:

$$(1) \qquad \left(\frac{Y}{L}\right)_i = \alpha_0 + \alpha_1\left(\frac{K}{L}\right)_i + \alpha_2 KQ_i + \alpha_3 LS_i + \beta' Z + \gamma OSS_i + \varepsilon_i,$$

where i refers to the ith firm and ε is the i.i.d. error term. Our empirical model, which examines the relationship between plant-level labor productivity and industry-level outsourcing intensity, is consistent with both the strand of literature that examines plant- (or firm-) level performance with country-level factors such as institutional quality (see Bhaumik et al., 2012, for a discussion of the literature) and the strand that examines the impact of industry-level outsourcing on micro variables such as individual wage rates (Geishecker and Görg, 2008).

We include in the vector $\boldsymbol{Z}$ controls for market competition (i.e., competition) and ownership (a dummy variable that takes the value 1 for foreign-owned plants), both of which can affect firm performance (Bhaumik and Estrin, 2007). The average value of the Herfindahl index for the 2000 sample of industries was 87, while that for the 2005 sample was 81. Foreign-owned plants accounted for about 8 percent and 11 percent of these samples, respectively. In addition, we control for the presence of a works council in the plant. Available evidence suggests that works councils can facilitate efficient enforcement of contractual agreements between managers and workers and thereby contribute to greater productivity (Addison, Schnabel, and Wagner, 2001). About 41 percent of the plants in the 2000 sample had works councils, and the corresponding figure for 2005 was 46 percent. We also include in the vector a control for location (a dummy variable that takes the value 1 when a plant is located in Eastern Germany) and distinguish between heavy and light industries (a dummy variable that takes the value 1 for light industries). About 30 percent of the plants in the 2000 sample and 26 percent of the plants in the 2005 sample are located in Eastern Germany.

As discussed later, we are able to use cross-sectional data for 2000 and 2005 for our estimation. In keeping with the literature, we need to consider the possibility that capital per employee, capital quality, and labor skills are endogenous. We have therefore used a two-stage instrumental variable estimation process. In the first stage, the potentially endogenous variables have been instrumented by past values of these variables and other exogenous variables such as firm age. In the second stage, labor productivity (and profitability) have been regressed on the measure of outsourcing, the instrumented values of the (potentially) endogenous variables, and the other control variables. The first-stage regressions are reported in Appendixes A2 and A3.

Measures of Outsourcing

We generate measures of outsourcing using balance of payments and input-output tables; details are reported in Table 2. Broadly speaking, we build on the research of Feenstra and

Table 2

Alternative Measures of Outsourcing

Outsourcing measure	Description
FH	Following the work of Feenstra and Hanson (FH, 1996, 1999), the first measure is calculated as the share of imported intermediate inputs to total non-energy inputs. FH do not have a direct measure of imported intermediate inputs from their data and, instead, estimate import intensity using final trade data from the IMF balance of payment statistics. A useful way to think about the FH measure is the sum of the input weight times import intensity, for all inputs into production. Thus, for each industry *i*, FH have $FH\_OSS_i = \sum_j \frac{[\text{input purchases of good } j \text{ by industry } i]}{[\text{total non-energy inputs by industry } i]} * \frac{[\text{imports of good } j]}{[\text{production}_j + \text{imports}_j - \text{exports}_j]}$, where for our measure all data come from the OECD. Imports and total production come from the total input-output table, such that each row of the column "imports" represents the total amount of each sector that is imported into the country for the given year. The important distinction is that this quantity does not equal the column sum from the import input-output table. FH consider only material purchases by manufacturing industries from other manufacturing industries. Presumably, this approach excludes input purchases from energy-intensive industries, such as ISIC code 8—namely, coke, refined petroleum products, and nuclear fuel. By extending the analysis to all 48 ISIC industries, energy industries are included. For the sake of completeness, we calculate the FH measure two ways, both including and excluding energy input purchases in the numerator. The results remain qualitatively the same, except as expected, for the two largest industries 2 (mining and quarrying) and 8 (coke, refined petroleum products, and nuclear fuel).
FH_narrow	FH also consider a narrow measure of outsourcing intensity, which consists of input purchases of goods within the same industry. This can be thought of as restricting input purchases to the diagonal of the input-output matrix. For the narrow measure of outsourcing, we do not make the distinction of energy/non-energy inputs in the numerator. A comparable comparison would be to simply exclude energy-intensive industries from consideration.
OECD	Using the OECD input-output tables, we generate a direct measure of imported intermediate inputs, which is exactly what FH and others have tried to estimate, by multiplying total intermediate inputs by an import intensity factor calculated from final trade data. The OECD (2008) defines offshoring as the share of non-energy imported intermediate inputs in total non-energy intermediate inputs: $OECD\_OSS_j = \sum_i \frac{x_m^{ij}}{\left(x_m^{ij} + x_d^{ij}\right)}$, where x_d^{ij} and x_m^{ij} are the domestic and imported intermediate inputs from sector *i* to sector *j*, respectively, and *i* excludes the energy sectors (mining and utility). The OECD ratios are expected to be slightly lower than the corresponding FH measures, since the FH measures use final data for imports and production. The final trade data also include value added from production and, hence, might overstate the importance of a given import.
OECD_narrow	This is the equivalent of FH's narrow measure of outsourcing, whereby only imports from the same industry are taken into consideration.

Table 2, cont'd

Alternative Measures of Outsourcing

Outsourcing measure	Description
GG	Geishecker and Görg (GG, 2008) construct a measure of outsourcing intensity by focusing on imported intermediate inputs but, in contrast to FH, normalize by total industry output value. This is an attempt to reconcile the difference between offshoring and domestic outsourcing, since (as GG point out) an increase in domestic outsourcing will lower the OSS measure in the FH and OECD calculations. By including value added in the denominator, as part of total output, GG argue that an increase in industry-level domestic input purchases will be countered by a decrease in industry-level value added. Hence, the GG measure of outsourcing intensity is $GG\_OSS_j = \frac{\sum_i X_m^{ij}}{Y_j}$, where X_m^{ij} represents the value of imported intermediate inputs from industry i to industry j and Y_j represents the total output value of the industry of interest. Note that, in contrast to FH, GG choose to include energy purchases in the denominator.
GG_narrow	This is the equivalent of FH's narrow measure of outsourcing, whereby only imports from the same industry are taken into consideration.

Hanson (1996, 1999) and define outsourcing as the share of imported intermediate inputs to total non-energy inputs. Our measures of outsourcing are a departure from the section of the literature that has used firm-level measures of outsourcing such as a firm-level binary indicator of change (increase) in the proportion of intermediate goods and services that are imported (Moser, Urban, and Weder di Mauro, 2009). The measures, however, are consistent with the wider literature on outsourcing and its impact on firm performance.

Table 3 shows the pairwise correlation among the different measures of outsourcing. With a few exceptions, the correlation coefficients are large and significant at the 10 percent level. Correlation is particularly high within wide and narrow measures of outsourcing. The observations made in the rest of this paper and the results reported should therefore not be influenced significantly by the choice of the outsourcing measure.

Figure 1 shows the Organisation for Economic Co-operation and Development (OECD) (standard or wide) measures of outsourcing for German manufacturing and service industries for 1995, 2000, and 2005.[4] The extent of outsourcing is higher in manufacturing industries than in service industries. For most manufacturing industries, the measure of outsourcing is between 20 percent and 40 percent, while for most service industries it is below 20 percent.[5] Further, the outsourcing intensity in both manufacturing and service industries has remained stable since 1995, suggesting that the popular wisdom that outsourcing is on the rise in developed country industries might require further investigation.

Other Variables

Estimating the impact of industry-level outsourcing intensity on plant-level labor productivity requires plant-level data on output, employment, location, ownership, etc. To this end, we use data provided by the Institute for Employment Research (IAB) at Nuremberg, Germany.

Table 3

Correlations Among Alternative Measures of Outsourcing

	OECD	OECD_narrow	GG	GG_narrow	FH	FH_narrow
1995						
OECD	1.00					
OECD_narrow	0.58*	1.00				
GG	0.82*	0.61*	1.00			
GG_narrow	0.62*	0.95*	0.55*	1.00		
FH	0.25	0.48*	0.72*	0.32*	1.00	
FH_narrow	0.50*	0.89*	0.62*	0.88*	0.61*	1.00
2000						
OECD	1.00					
OECD_narrow	0.55*	1.00				
GG	0.74*	0.80*	1.00			
GG _narrow	0.70*	0.83*	0.60*	1.00		
FH	0.12	0.61*	0.71*	0.15	1.00	
FH_narrow	0.55*	0.86*	0.70*	0.85*	0.61*	1.00
2005						
OECD	1.00					
OECD_narrow	0.58*	1.00				
GG	0.60*	0.66*	1.00			
GG_narrow	0.72*	0.92*	0.53*	1.00		
FH	0.18	0.51*	0.84*	0.28*	1.00	
FH_narrow	0.61*	0.87*	0.72*	0.84*	0.64*	1.00

NOTE: Pair-wise correlations; * indicates significance at the 10 percent level.

Specifically, we use 2000 and 2005 rounds of the IAB Establishment Panel, a longitudinal survey that currently contains data on approximately 16,000 German firms (for details, see Fischer et al., 2008). The survey, which is the basis for a wide range of policy-related research, has two important limitations. First, because of a change in the classification system for economic activities, data are comparable for the 1993-99 period and thereafter for 2000 and the later years—hence our decision to restrict our analysis of labor productivity to 2000 and 2005. Second, the data provide information about investment flows for the years of the survey; there is no information on capital stock. Since it is stylized to use capital stock as an explanatory variable in any regression model involving labor productivity, we had to compute plant-level capital stocks using other data sources.

We experimented with two different approaches to computing plant-level values of capital stock. We first used the German KLEMS data[6] to compute industry-level capital-output ratios for 1995 and used these ratios to compute approximate values of plant-level capital stock, given data on plant-level output. We then used the data on investment flows and depreciation, and the perpetual inventory method, to compute plant-level values of capital stock for the subse-

Figure 1

OECD (standard) Measure of Outsourcing Intensity

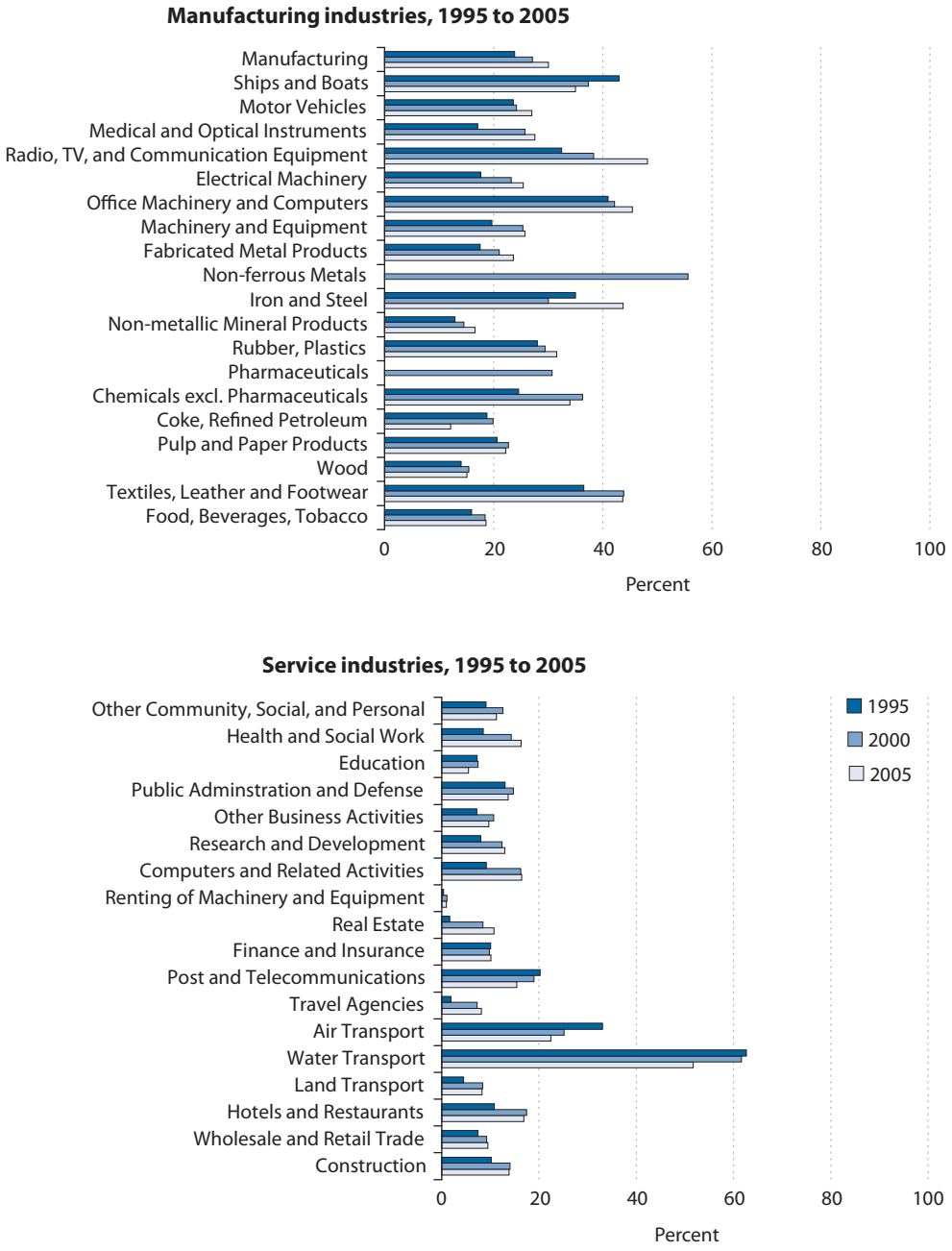


Table 4

Impact of Outsourcing on Labor Productivity

	2000	2005
Outsourcing	2.69***	2.22***
	(0.08)	(0.05)
Factor inputs		
(Log) Capital per employee	0.97***	0.95***
	(0.005)	(0.005)
Quality of capital	0.03***	0.03***
	(0.007)	(0.007)
Labor skill	0.002	0.009
	(0.02)	(0.01)
Other controls		
Market concentration	–0.0004***	–0.0003***
	(0.00003)	(0.00002)
East German location	0.007	0.006
	(0.01)	(0.007)
Works council at the firm	–0.0004	0.02***
	(0.007)	(0.007)
Foreign ownership	0.01	0.006
	(0.01)	(0.01)
Light industry	0.09***	0.17***
	(0.01)	(0.01)
Constant	–4.59***	–4.43***
	(0.05)	(0.05)
Anderson chi-square statistic	317.79***	553.44***
Sargan chi-square statistic	0.21	0.11
F-statistic	5748.77***	6713.96***
Centered *R*-squared	0.98	0.97
No. of observations	949	1899

NOTE: (Log) capital per employee, quality of capital, and labor skill are instrumented. Values within parentheses are robust standard errors; ***, **, and * indicate significance at the 1, 5, and 10 percent levels, respectively.

quent years. However, the generated data had high variance, and we therefore opted for a simpler method to compute plant-level capital stock for 2000 and 2005. Specifically, we used the industry-level capital output ratios for 2000 and 2005, obtained from the German KLEMS data, to compute plant-level capital stocks for these years, given the data on plant-level output. Detailed information about industry classification that was necessary to match industry-level capital-output ratios generated from KLEMS data with plant-level information was provided by IAB.

The data for industry-level measures of competition, namely, the Herfindahl index, was provided by the German Monopolkommission. The Monopolkommission also provided information on industry classification used for computing the Herfindahl indexes. This enabled us to match the plant-level information to the data on industry-level competition.

REGRESSION RESULTS

Our regression results are reported in Table 4. We report the regression results for 2000 and 2005 alone. As mentioned earlier, on account of a change in the classification system for economic activities, data are comparable for the 1993-99 period and thereafter for 2000 and the later years. Further, as explained in footnote 5, we use lagged values of variables to instrument potential endogenous variables, and absence of lagged values of appropriate variables limits our ability to estimate a two-stage least-squares model for 1995. For 2000 and 2005, the *F*-statistics suggest that the estimated models are very meaningful in the context of the data. Indeed, despite the reduced efficiency of the regressions, on account of instrumenting, most of the explanatory variables are significant at the 1 percent level. Further, the statistics for the Anderson test for underidentification and the Sargan test for overidentifying restrictions suggest that the choice of instruments was appropriate.[7]

The results are also meaningful from the point of view of economic theory. They suggest that labor productivity is positively related to capital per employee and capital quality. The results indicate that the capital-per-employee elasticity of labor productivity is 0.97; that is, any increase in capital per employee results in a proportional change in labor productivity. The impact of capital quality on labor productivity is much weaker. Productivity is inversely related to market concentration; that is, it is higher in competitive markets. This is consistent with the wider literature on the impact of competition on productivity. Labor productivity is higher for firms in the light industries than those in the heavy industries. The link between works councils and productivity is not strong, but there is a significant positive relationship in 2005. This has interesting implications about the debate on the impact of labor market institutions on firm performance and is consistent with the argument that institutions that offer workers greater protection can improve productivity (Bhaumik et al., 2012).

Most importantly, outsourcing has both a statistically significant and economically meaningful impact on labor productivity. No other variable affects labor productivity as much; the impact of outsourcing is more than 2.5 times higher than the impact of the next most important factor, namely, capital per employee. This positive relationship between outsourcing and labor productivity is consistent with the evidence in the wider literature. As highlighted in Table 1, earlier research established a positive relationship between outsourcing and productivity (and its growth) in countries such as Ireland (Görg and Hanley, 2005) and the United Kingdom (Girma and Görg, 2004). While the overall evidence about the impact of outsourcing on productivity remains mixed, our results strengthen the arguments that emphasize the favorable aspects of outsourcing.

To recapitulate, our regression model has (log) labor productivity (Y/L) as the dependent variable and a measure of outsourcing (OSS) that is bounded by zero and 1 as an explanatory variable. The marginal impact of outsourcing on labor productivity, therefore, is given by

$$\frac{1}{Y/L}\frac{\partial(Y/L)}{\partial OSS} = 2.69 \text{ for 2000 and } \frac{1}{Y/L}\frac{\partial(Y/L)}{\partial OSS} = 2.22 \text{ for 2005.}$$

At the mean value for labor productivity, therefore, the marginal impact of an increase in (industry level) outsourcing

intensity on (plant level) labor productivity, $\frac{\partial(Y/L)}{\partial OSS}$, can be significant. This contradicts earlier findings that the marginal impact of outsourcing intensity on firm-level labor productivity is quite small (Criscuolo and Leaver, 2005). While it is not possible to reach strong conclusions on the impact of outsourcing on firm-level productivity based on a single empirical investigation, or indeed a handful of contradictory empirical results, our results suggest that there is scope for optimism about the beneficial aspects of outsourcing.

CONCLUSION

Outsourcing and offshoring have become increasingly volatile political issues in the developed economies of North America and Europe, in large measure on account of the rising or high and stagnant unemployment rates in these economies. Yet, the empirical literature on the impact of outsourcing on firms, while growing, is still somewhat small, and there is no consensus in this literature about the impact of outsourcing on firm performance. We extend this literature using plant-level data from the manufacturing sector in Germany, whose ability to benefit from outsourcing is not fully obvious. We find that the extent of outsourcing is higher among the manufacturing industries in Germany than among the service industries and that the outsourcing intensity of these industries did not change much between 1995 and 2005. We also find a significantly positive and economically meaningful impact of industry-level outsourcing intensity on plant-level labor productivity, for both 2000 and 2005.

Our research has certain shortcomings. We observe outsourcing intensity at the industry level rather than at the plant level, and we have a noisy measure of plant-level capital. However, our analysis provides some *prima facie* evidence about outsourcing intensity of German industries and the outsourcing-productivity link in Germany. It therefore provides the basis for further inquiry into the outsourcing phenomenon.

NOTES

1 The new institutional economics literature suggests that the choice between outsourcing and producing all components of the final product internally also depends on asset specificity of the intermediate products that are outsourced and the corresponding governance costs of the outsourcing contracts (Holmstrom and Roberts, 1998, and Williamson, 2002). Grossman and Helpman (2002) argue that the transactions cost approach to outsourcing is inadequate because it treats as given the industry environment within which a firm operates. They demonstrate that the extent of outsourcing depends on the search costs that are incurred by the firms to find appropriate vendors, the relative bargaining powers of the firms deciding on outsourcing and the vendors supplying the (intermediate) goods and services, and the elasticity of demand of the (final) consumer good. However, neither of these two strands of the literature discusses the impact of outsourcing on firm performance, especially productivity.

2 The literature examines the impact of outsourcing both on firm- and plant-level productivity, and there is some indication that firm- and plant-level effects might indeed differ. We use plant-level data later in the article; however, in the discussion, we use "firm-level" and "plant-level" interchangeably.

3 To date, the majority of the economic literature has emphasized the impact of outsourcing on manufacturing firms (Olsen, 2006; Amiti and Wei, 2006; Görg and Hanley, 2005; Egger and Egger, 2006), but Daveri and Jona-Lasinio (2008) considered the impact of outsourcing manufacturing and services on the Italian economy between 1995 and 2003. They found that services outsourcing was not correlated with labor productivity but noted that their findings were

not robust to different measures of services outsourcing. In keeping with the primary literature, and remaining cognizant of the potential for measurement error with service industries highlighted by Daveri and Jona-Lasinio (2008), we consider the impact of outsourcing on manufacturing firms.

[4] The underlying figures for the manufacturing sector, which is the focus of our analysis, are reported in Appendix A1.

[5] The services sector outsources a wide range of services including ICT services, administrative services, sales, and after-sales services (through call centers, for example), etc. The U.S. financial services industry, for example, may have outsourced as much as 15 percent of their overall cost base (see Basel Committee on Banking Supervision, 2005).

[6] The EU KLEMS Growth and Productivity Accounts contain industry-level data on output, inputs, and productivity for 25 European countries, Japan, and the United States. Details about the methodology used to assemble the data can be found in O'Mahony and Timmer (2009).

[7] The first stage IV regressions for the three variables, which we treat as endogenous, namely, capital per employee (*K*/*L*), capital quality (*KQ*), and labor skill (*LS*), are reported in Appendixes A2 and A3. The first stage IV regressions suggest that lagged values of the endogenous variables are generally the best instruments for the 2000 and 2005 values of these variables. The use of past values of variables as instruments is fairly common in the literature. We experimented with longer lags of these variables, but the use of the shorter (one-period) lag was sufficient for our purposes, and the use of such short lags is also desirable for the credibility of the two-stage least-squares estimates (see Murray, 2006).

REFERENCES

Addison, John T.; Schnabel, Claus and Wagner, Joachim. "Work Councils in Germany: Their Effects on Establishment Performance." *Oxford Economic Papers*, October 2001, *53*(4), pp. 659-94.

Amiti, Mary and Wei, Shang-Jin. "Service Offshoring and Productivity: Evidence from the United States." NBER Working Paper No. 11926, National Bureau of Economic Research, October 2006; www.nber.org/papers/w11926.pdf.

Bachmann, Ronald and Braun, Sebastian. "The Impact of International Outsourcing on Labour Market Dynamics in Germany." *Scottish Journal of Political Economy*, February 2011, *58*(1), pp. 1-28.

Basel Committee on Banking Supervision. "Outsourcing in Financial Services." Basel, Switzerland: Bank for International Settlements, February 2005; www.bis.org/publ/joint12.htm.

Barthélemy, Jérôme. "The Hidden Costs of IT Outsourcing." *MIT Sloan Management Review*, Spring 2001, *42*(3), pp. 60-69.

Bhaumik, Sumon Kumar. "Productivity and the Economic Cycle." BIS Economics Paper No. 12, Bank for International Settlements Department for Business Innovation and Skills, March 2011; www.bis.gov.uk/assets/biscore/economics-and-statistics/docs/p/11-772-productivity-and-the-economic-cycle.

Bhaumik, Sumon Kumar; Dimova, Ralitza; Kumbhakar, Subal C. and Sun, Kai. "Does Institutional Quality Affect Firm Performance? Insights from a Semiparametric Approach." IZA Discussion Paper No. 6351, Institute for the Study of Labor, 2012; http://ftp.iza.org/dp6351.pdf.

Bhaumik, Sumon Kumar and Estrin, Saul. "How Transition Paths Differ: Enterprise Performance in Russia and China." *Journal of Development Economics*, March 2007, *82*(2), pp. 374-92.

Criscuolo, Chiara and Leaver, Mark. "Offshore Outsourcing and Productivity." Unpublished manuscript, 2005; www.oecd.org/dataoecd/55/23/35637436.pdf.

Daveri, Francesco and Jona-Lasinio, Cecilia. "Off-Shoring and Productivity Growth in the Italian Manufacturing Industry." *CESifo Economic Studies*, September 2008, *54*(3), pp. 414-50.

Directorate-General for Economic and Financial Affairs. "Impact of the Current Economic and Financial Crisis on Potential Output." Occasional Paper No. 49, European Commission, June 2009; http://ec.europa.eu/economy_finance/publications/publication15479_en.pdf.

Egger, Hartmut and Egger, Peter H. "International Outsourcing and the Productivity of Low-Skilled Labor in the EU." *Economic Inquiry*, January 2006, *44*(1), pp. 98-108.

Farrell, Diana. "Can Germany Win from Offshoring?" McKinsey Global Institute, July 2004.

Feenstra, Robert C. and Hanson, Gordon H. "Globalization, Outsourcing, and Wage Inequality." *American Economic Review*, May 1996, *86*(2), pp. 240-45.

Feenstra, Robert C. and Hanson, Gordon H. "The Impact of Outsourcing and High-Technology Capital on Wages: Estimates for the United States, 1979-1990." *Quarterly Journal of Economics*, August 1999, *114*(3), pp. 907-40.

Fischer, Gabriele; Janik, Florian; Müller, Dana and Schmucker, Alexandra. "The IAB Establishment Panel—From Sample to Survey to Projection." FDZ Working Paper No. 01/2008, The Research Data Centre (FDZ) of the Federal Employment Service, Institute for Employment Research, 2008; http://doku.iab.de/fdz/reporte/2008/MR_01-08_en.pdf.

Furceri, Davide and Mourougane, Annabelle. "The Effect of Financial Crises on Potential Output: New Empirical Evidence from OECD Countries." OECD Economics Department Working Paper No. 699, OECD, Organisation for Economic Co-operation and Development, 2009; www.oecd-ilibrary.org/docserver/download/fulltext/5ksj3lqk2h40.pdf?expires=1338557881&id=id&accname=guest&checksum=A58AA934D8DDFEDAC96BD882A2849DCC.

Geishecker, Ingo and Görg, Holger. "Winners and Losers: A Micro-Level Analysis of International Outsourcing and Wages." *Canadian Journal of Economics*, February 2008, *41*(1), pp. 243-70.

Girma, Sourafel and Görg, Holger. "Outsourcing, Foreign Ownership, and Productivity: Evidence from UK Establishment-Level Data." *Review of International Economics*, November 2004, *12*(5), pp. 817-32.

Görg, Holger and Hanley, Aoife. "Does Outsourcing Increase Profitability." *Economic and Social Review*, 2004, *35*(3), pp. 267-88.

Görg, Holger and Hanley, Aoife. "International Outsourcing and Productivity: Evidence from the Irish Electronics Industry." *North American Journal of Economics and Finance*, August 2005, *16*(2), pp. 255-69.

Görg, Holger; Hanley, Aoife and Strobl, Eric. "Productivity Effects of International Outsourcing: Evidence from Plant-Level Data." *Canadian Journal of Economics*, May 2008, *41*(2), pp. 670-688.

Görzig, Bernd and Stephan, Andreas. "Outsourcing and Firm-Level Performance." Discussion Paper No. 309, DIW Berlin, German Institute for Economic Research, October 2002; http://repec.org/res2003/Gorzig.pdf.

Grossman, Gene M. and Helpman, Elhanan. "Integration Versus Outsourcing in Industry Equilibrium." *Quarterly Journal of Economics*, February 2002, *117*(1), pp. 85-120.

Hijzen, Alexander; Inui, Tomohiko and Todo, Yasuyuki. "Does Offshoring Pay? Firm-Level Evidence from Japan." *Economic Inquiry*, October 2010, *48*(4), pp. 880-95.

Holmström, Bengt and Roberts, John. "The Boundaries of the Firm Revisited." *Journal of Economic Perspectives*, Fall 1998, *12*(4), pp. 73-94.

Keuschnigg, Christian and Ribi, Evelyn. "Outsourcing, Unemployment and Welfare Policy." *Journal of International Economics*, June 2009, *78*(1), pp. 168-76.

Kurz, Christopher J. "Outstanding Outsourcers: A Firm- and Plant-Level Analysis of Production Sharing." Finance and Economics Discussion Series Working Paper No. 2006-04, Division of Research & Statistics and Monetary Affairs, Board of Governors of the Federal Reserve System, 2006; www.federalreserve.gov/pubs/feds/2006/200604/200604pap.pdf.

Moser, Christoph; Urban, Dieter and Weder di Mauro, Beatrice. "Offshoring, Firm Performance and Establishment-Level Employment: Identifying Productivity and Downsizing Effects." CEPR Discussion Paper No. DP7455, Centre for Economic Policy Research, September 2009.

Murray, Michael P. "Avoiding Invalid Instruments and Coping with Weak Instruments." *Journal of Economic Perspectives*, Fall 2006, *20*(4), pp. 111-32.

O'Mahony, Mary and Timmer, Marcel P. "Output, Input and Productivity Measures at the Industry Level: The EU KLEMS Database." *Economic Journal*, June 2009, *119*(538), pp. F374-F403.

Olsen, Karsten B. "Productivity Impacts of Offshoring and Outsourcing: A Review." STI Working Paper No. 2006/1, OECD Directorate for Science, Technology and Industry (STI), Organisation for Economic Co-operation and Development, March 2006; www.oecd.org/dataoecd/16/29/36231337.pdf.

Tomiura, Eiichi. "Foreign Outsourcing, Exporting, and FDI: A Productivity Comparison." *Journal of International Economics*, May 2007, *72*(1), pp. 113-27.

Wagner, Joachim. "Offshoring and Firm Performance: Self-Selection, Effects on Performance, or Both?" *Review of World Economics*, June 2011, *147*(2), pp. 217-47.

Williamson, Oliver E. "The Theory of the Firm as Governance Structure: From Choice to Contract." *Journal of Economic Perspectives*, Summer 2002, *16*(3), pp. 171-95.

Wilmot, Jill. "Outsourcing Is Key to Surviving the Downturn: The Capgemini Executive Outsourcing Survey Conducted by Harris Interactive." Capgemini, 2009; www.us.capgemini.com/insights-resources/publications/outsourcing-is-key-to-surviving-the-downturn—the-capgemini-executive-outsourcing-survey-conducted-by-harris-interactive/.

Zhang, Ting. "International Outsourcing and Unemployment in a Minimum-Wage Economy." *Review of International Economics*, September 2011, *19*(4), pp. 776-86.

APPENDIX A1

Outsourcing Intensity for Manufacturing Industries in Germany (percent)

	1995				2000				2005			
Industry	FH	FH excl. energy	GG	OECD	FH	FH excl. energy	GG	OECD	FH	FH excl. energy	GG	OECD
Food, beverages, tobacco	15.54	15.14	11.44	15.95	18.76	18.22	13.20	18.42	21.31	20.54	13.46	18.60
Textiles, leather and footwear	34.49	34.07	23.65	36.50	40.87	40.30	28.53	43.86	47.04	46.16	28.06	43.69
Wood	18.78	18.32	8.73	14.01	23.58	22.97	9.45	15.40	28.23	27.34	10.18	15.11
Pulp and paper products	14.61	14.03	12.22	20.63	19.65	18.87	13.46	22.69	23.12	22.00	13.30	22.17
Coke, refined petroleum	167.62	9.87	49.60	18.77	227.30	14.03	63.66	19.90	243.14	17.33	65.26	12.12
Chemicals excl. pharmaceuticals	27.18	24.35	15.50	24.56	34.64	30.83	25.44	36.27	44.78	40.23	23.54	33.97
Pharmaceuticals*	0.00	0.00			0.00	0.00	18.87	30.72	0.00	0.00		
Rubber, plastics	27.93	26.73	16.30	27.99	36.39	34.79	17.40	29.38	46.68	44.56	18.60	31.55
Non-metallic mineral products	16.48	14.82	7.37	12.88	20.88	18.65	9.13	14.54	26.96	24.08	10.91	16.52
Iron and steel	30.89	28.68	22.84	34.98	37.25	34.28	21.46	30.02	46.14	42.45	31.58	43.72
Non-ferrous metals*	0.00	0.00			0.00	0.00	40.64	55.65	0.00	0.00		
Fabricated metal products	22.47	22.10	10.09	17.53	28.12	27.62	11.67	21.01	35.21	34.46	13.52	23.59
Machinery and equipment	24.59	24.42	11.62	19.62	33.76	33.53	15.12	25.36	44.08	43.74	15.64	25.74
Office machinery and computers	33.84	33.70	26.47	40.95	42.71	42.53	31.15	42.16	54.22	53.96	31.90	45.44
Electrical machinery	23.79	23.61	10.46	17.62	31.70	31.46	13.64	23.23	39.71	39.32	15.95	25.43
Radio, TV, and communication equipment	31.83	31.71	21.02	32.43	43.57	43.41	25.18	38.34	54.50	54.23	30.82	48.18
Medical and optical instruments	24.50	24.29	8.77	17.06	32.59	32.31	13.24	25.74	43.83	43.40	13.58	27.56
Motor vehicles	33.75	33.62	15.68	23.62	39.04	38.86	18.35	24.18	47.62	47.35	20.25	26.99
Ships and boats	40.86	40.71	28.99	42.98	53.66	53.45	25.37	37.34	56.57	56.26	23.04	35.01
Manufacturing	18.76	18.35	14.26	23.80	24.56	24.00	16.57	27.07	29.43	28.65	18.68	30.00

NOTE: *Raw data from OECD input-output tables were available for all industries during all time periods to calculate outsourcing measures. Missing data in the numerator is expressed as a zero; missing data in the denominator is expressed as missing. See Table 2 for a description of each OSS methodology.

APPENDIX A2

First Stage IV Regressions for 2000

	K/L	KQ	LS
Firm age	0.03	0.06	0.04***
	(0.02)	(0.05)	(0.01)
Outsourcing	–0.38	0.57	0.14
	(0.24)	(0.50)	(0.13)
Market concentration	0.0001	0.00004	–0.00001
	(0.0001)	(0.0002)	(0.00005)
East German location	–0.12***	–0.03	0.02
	(0.03)	(0.06)	(0.01)
Foreign ownership	–0.02	–0.07	–0.03
	(0.03)	(0.07)	(0.02)
Works council at the firm	0.11***	–0.04	0.01
	(0.02)	(0.05)	(0.01)
Light industry	0.02	0.08	–0.01
	(0.03)	(0.06)	(0.02)
(Lag) Capital per employee	0.90 ***	0.05*	0.02**
	(0.01)	(0.03)	(0.01)
(Lag) Capital quality	0.001	0.56***	0.006
	(0.01)	(0.02)	(0.007)
(Lag) Labor skill	0.02	–0.13	0.70***
	(0.04)	(0.08)	(0.02)
Constant	0.88***	1.07	–0.12
	(0.16)	(0.32)	(0.08)
F-statistic	580.29***	52.02***	115.01***
Centered *R*-squared	0.86	0.35	0.55

NOTE: The values within parentheses are robust standard errors; ***, **, and * indicate significance at the 1, 5, and 10 percent levels, respectively.

APPENDIX A3

First Stage IV Regressions for 2005

	K/L	KQ	LS
Firm age	–0.0009	0.02	0.04***
	(0.01)	(0.03)	(0.01)
Outsourcing	–0.21*	0.03	0.03
	(0.12)	(0.02)	(0.07)
Market concentration	0.00005	0.00001	–0.00003
	(0.00006)	(0.0001)	(0.00003)
East German location	–0.05***	0.04	0.009
	(0.02)	(0.03)	(0.01)
Foreign ownership	0.04*	–0.09*	–0.004
	(0.02)	(0.05)	(0.01)
Works council at the firm	0.11***	–0.06	0.003
	(0.02)	(0.03)	(0.01)
Light industry	–0.01	–0.07	–0.02
	(0.02)	(0.05)	(0.01)
(Lag) Capital per employee	0.88***	0.09***	0.007
	(0.01)	(0.02)	(0.006)
(Lag) Capital quality	0.02*	0.55***	–0.009*
	(0.0009)	(0.02)	(0.005)
(Lag) Labor skill	0.07***	–0.005	0.70***
	(0.02)	(0.05)	(0.02)
Constant	0.87***	0.92	0.07
	(0.11)	(0.23)	(0.06)
F-statistic	1201.19***	88.49***	216.90***
Centered *R*-squared	0.86	0.32	0.53

NOTE: The values within parentheses are robust standard errors; ***, **, and * indicate significance at the 1, 5, and 10 percent levels, respectively.

Close

Craig Aubuchon

Indiana University School of Public and Environmental Affairs

Research Focus

Craig Aubuchon was a research associate with the Federal Reserve Bank of St. Louis from 2007 to 2010. He recently graduated from Indiana University with master's degrees in public administration and environmental science. His current research uses benefit-cost analysis and applied econometrics to understand the economic value of water resources.

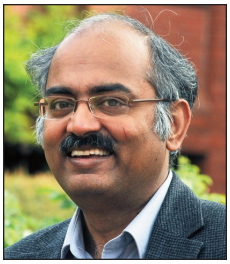
Subhayu Bandyopadhyay

Research officer and economist, Federal Reserve Bank of St. Louis

http://research.stlouisfed.org/econ/bandyopadhyay/

Research Focus

Subhayu Bandyopadhyay's main areas of research are international trade theory and international development. His recent research also includes contributions to the economic analysis of terrorism.



Sumon Kumar Bhaumik

Reader in the Economics and Strategy Group, Aston Business School, Aston University, Birmingham, U.K.

Research Focus

Sumon Bhaumik's research encompasses a number of areas within economics, finance, and international business. In the recent past, his research has focused on implications of ownership structures on both performance (e.g., M&A outcomes) and strategic decisions (e.g., likelihood and direction of overseas investment) of firms. He has also examined issues such as financing constraints among firms and cross-ownership differences in the impact of monetary policy on credit disbursal by banks.

Withdrawal History, Private Information, and Bank Runs

Carlos Garriga and Chao Gu

This paper provides a simple two-depositor, two-stage model to understand how a bank's withdrawal history affects an individual's decision about withdrawals, which could possibly trigger bank runs. Individual depositors have private information about their personal consumption types and receive noisy private signals about the quality of the bank's portfolio. Depositors make publicly observable withdrawal decisions in sequence. Computed examples indicate that the optimal contract contingent on withdrawal histories can tolerate bank runs. These runs are triggered by unfavorable signals about a bank's portfolio, and early liquidation of unsuccessful investments can avoid future losses. Because the signals are private, a depositor's action is the only way to partially reveal his private information. A run-admitting bank contract allows information to be revealed. However, if signals are too noisy, bank runs may occur too often when fundamentals are strong. In this case, a bank would offer a run-proof contract. Given the relevant role of information, a policy that makes private information public would be useful to improve welfare and eliminate bank runs. (JEL C73, D82, E59, G21)

Federal Reserve Bank of St. Louis *Review*, July/August 2012, *94*(4), pp. 305-20.

The recent financial crises have drawn considerable attention on the regulation of financial intermediaries. One question that arises is whether bank runs should be prevented in *any* circumstance. To answer this question, we first need to understand the underlying conditions that prompt bank runs. One strand of the literature, following Diamond and Dybvig (1983), argues that banks and bank runs are inherently intertwined because banks' contracts provide short-term liquidity, whereas banks' portfolios mature only in the long term. As a result, a panic-based bank run is self-fulfilling even in the absence of uncertainty about fundamentals and is not efficient. Some institutional arrangements—for example, deposit insurance or the promise from the central bank to serve as the lender of last resort—can prevent panic-based bank runs by providing sufficient liquidity should a run occur.

Another strand in the literature attributes the runs to fundamentals.[1] The view on fundamental-based bank runs argues that bank runs occur when depositors receive negative information about their bank's portfolio returns or about an aggregate liquidity shock. Unlike

Carlos Garriga is a research officer and economist at the Federal Reserve Bank of St. Louis. Chao Gu is an assistant professor of economics at the University of Missouri–Columbia; she thanks Karl Shell for guidance.

panic-based runs, fundamental-based runs are not necessarily inefficient because liquidating unsuccessful investments early can mitigate future losses.

In both strands of the literature, the arrival of information is the factor that determines whether a bank run occurs. For panic-based bank runs, the realization of an exogenous variable, called a sunspot, can trigger a bank panic.[2] For fundamental-based runs, depositors lose confidence when there is unfavorable news about their bank's performance. In either approach it is generally assumed that upon receiving information depositors need to make a simultaneous withdrawal decision without observing the actions of others.

In reality, at least some withdrawals are based on the information about previous withdrawals by others.[3] This sequential process of learning from the observed withdrawal history is important to understand not only bank runs, but also whether banks can use the process of revelation of information to design their deposit contracts.

The objective of this paper is to understand how a bank's withdrawal history affects an individual's decision about withdrawals, which could possibly trigger bank runs. A dynamic model is necessary to formalize the revelation of the withdrawal history. The model is a simple two-stage game with two depositors and private information. In the game, bank runs are driven by signals on the fundamentals as opposed to sunspots.

In the model, the depositors receive a private signal about their liquidity needs and a private noisy signal about the quality of the bank's portfolio. Depositors make withdrawal decisions in sequence at a given stage and the withdrawal decisions are publicly observable. The first depositor's action to withdraw or to wait can partially reveal his private signal about the bank's portfolio, which affects the belief of the second depositor and thus his withdrawal decision. Under some parameterization, the optimal contract admits an equilibrium in which depositors' strategies are contingent on their private signals and observed withdrawals.

A dynamic model explains some empirical results on bank runs that cannot be explained by a static model. For example, during the 2001 run on Turkish special finance houses,[4] depositors made sequential withdrawals influenced by the history of withdrawals by others, as noted by Starr and Yilmaz (2007, p. 1114): "Increased withdrawals by moderate-size account holders tended to boost withdrawals by [their] small counterparts, suggesting that the latter viewed the former as informative with respect to the SFH's [special finance house's] financial condition."[5,6]

Our model, although simple, sheds some light on whether bank runs should be completely prevented in an environment of private information. Computed examples show that in some economies a contract that permits bank runs is optimal, whereas in other economies a run-proof contract is optimal. This result is in line with the literature proposing that, if the probability of bank runs is low, a bank contract tolerates bank runs as depositors receive more consumption insurance during normal times. Furthermore, in the environment considered here, a bank run is driven by the information about a bank's portfolio return. In other words, it is driven by fundamentals. When fundamentals are weak, it is optimal for the bank to liquidate its portfolio to avoid future losses.

Since information is private, the only way that depositors can reveal their information is by their actions. A run-admitting contract allows depositors to do so, whereas a run-proof contract does not. However, (i) because a depositor's decision to withdraw carries noisy information about the signals he receives (the depositor might need to consume immediately or might receive an

unfavorable signal about the quality of the bank's portfolio)[7] and (ii) because the information itself is imperfect, bank runs can occur when fundamentals are strong. In these cases, runs are misled. If the probability of such misled runs is high, a run-proof contract is better.

The payments to the depositors in our model have two functions. First, they price fundamental risks. Second, depending on the quality of information, they give depositors an incentive to reveal or to hide their private information. Our results imply that pricing risk and incentive appropriately is the key to making financial markets efficient,[8] although ex post inefficient runs can occur as a result of imperfect information.

To show the importance of information, it is useful to solve a numerical example where signals on portfolio returns are public and compare it with the one with private signals. With public signals welfare is higher and, most importantly, there are no bank runs.[9] Hence, policymakers may make more effort to publicize the information of the fundamentals to improve welfare.

We focus on the numerical examples that yield a unique equilibrium. Hence, there is no sunspot-driven run (or panic-based run) in this paper. Although some bank runs occur when fundamentals are strong, since the runs are triggered by (imperfect) signals on fundamentals, these are still fundamental-based runs in our view.

Runs on commercial banks have been rare in the United States since the introduction of deposit insurance. However, runs on the shadow banking system were the important events in the recent financial crisis (see Gorton, 2010, and Anderson and Gascon, 2009). Our model, which uses the customary terminology in the literature with regard to bank runs, applies to general financial intermediaries subject to systemic financial crises.

The rest of the paper is organized as follows: The next section introduces the model setup and is followed by a discussion of the equilibrium given a banking contract. Next we calculate some examples of optimal contracts and then offer an example of an optimal contract in an economy with public signals. The final section summarizes our findings and conclusion.

THE MODEL

Time. There are three periods, indexed by $t = 0,1,2$. Period 0 is a planning period called ex ante. Periods 1 and 2 are ex post periods. Period 1 is divided into two stages.

Depositors' endowment and preferences. There are two depositors. Each depositor is endowed with one unit of consumption good ex ante and nothing ex post. Each depositor has probability α to become impatient in period 1 and probability $1-\alpha$ to be patient. An impatient depositor values consumption only at $t = 1$. His utility is described by $u(c_1)$, where c_1 is the consumption at $t = 1$. A patient depositor's utility is described by $u(c_1 + c_2)$, where c_2 denotes the consumption at $t = 2$. The utility function is strictly increasing, strictly concave, and twice differentiable. The coefficient of relative risk aversion, $xu'(x)/u''(x)$, is greater than 1 when $x \geq 1$. Whether a depositor is patient or impatient is revealed to the individual depositor at some stage in period 1.

Technologies. The consumption good can be stored at no cost. It can also be invested in a risky technology. The investment must be made ex ante and takes two periods to mature. The return on the investment can be either $\bar{R} > 1$ or $\underline{R} < 1$ at $t = 2$. The ex ante probability of receiving $\bar{R}$ is p_0. If the investment is liquidated at $t = 1$, the return is 1. Because the investment yields the

same return as storage at $t = 1$, all consumption goods will be placed in the risky technology at $t = 0$ and will be partially or fully liquidated at $t = 1$, depending on the events occurring at $t = 1$.

Withdrawal stages and information. Period 1 is divided into two stages. At each stage, one depositor is informed of a pair of signals. One signal tells him precisely his consumption type; the other imperfectly tells him the investment returns. The signal on investment return is accurate with probability q, where $q \geq 0.5$. That is,

$$\Pr\left(S_i = H \mid R = \overline{R}\right) = \Pr\left(S_i = L \mid R = \underline{R}\right) = q,$$

where S_i denotes depositor i's private signal of investment return. Depositors have an equal chance to receive signals at stage 1. The depositor who receives the signals at the first stage is called depositor 1; the other is depositor 2.

Each depositor can make withdrawals when he receives signals in period 1. If he does not withdraw in period 1, he receives payment in period 2. For convenience, a depositor can withdraw in period 1 only at the stage when he receives information. Depositors' actions are publicly observable.[10] Because there are only two depositors and two stages, allowing depositors to withdraw at any stage adds only two possible simultaneous-move games to each stage and does not change the main results.

The contract. A competitive bank offers a contract to depositors ex ante. For convenience, the minimum deposit amount that the bank accepts is one unit of a consumption good. The bank allocates the funds between storage and investment and makes payments to depositors upon withdrawals. The banking contract considered here pays depositors contingent on the withdrawal history.[11,12] The contract specifies the payments to withdrawals at $t = 1$ depending on the number of withdrawals that have been made and the payments to withdrawals at $t = 2$ depending on the number of withdrawals at $t = 1$ and the return on investment. Let $x_i \in \{0,1\}$ denote depositor i's action in period 1, where 0 indicates wait and 1 indicates withdraw. Let $c^1(x_1)$ be the payment to depositor 1 at stage 1, where $c^1(0) = 0$, and let $c^1(x_1,x_2)$ denote payment to depositor 2 at stage 2, where $c^1(x_1,0) = 0$. Similarly, let $c^2(x_1,x_2,R)$ denote payments at $t = 2$. All instances of c^1 and c^2 satisfy the following resource constraints:

$$c^1\left(x_1\right) + c^1\left(x_1, x_2\right) \leq 2, \tag{1}$$

$$\left(2 - x_1 - x_2\right)c^2\left(x_1, x_2, R\right) \leq \left[2 - c^1\left(x_1\right) - c^1\left(x_1, x_2\right)\right]\max\left\{1, R\right\}, \tag{2}$$

$$\left(2 - x_1 - x_2\right)c^2\left(x_1, x_2, R\right) \geq \left[2 - c^1\left(x_1\right) - c^1\left(x_1, x_2\right)\right]\min\left\{1, R\right\}. \tag{3}$$

Timing of the banking game. The timeline of the banking game can be summarized as follows:

$t = 0$:

- The bank announces the contract.
- Depositors make deposit decisions.

$t = 1$:

Stage 1:

- Depositor 1 receives signals about his consumption type and productivity.
- He decides whether to withdraw.

Stage 2:

- Depositor 2 receives signals about his consumption type and productivity.
- He decides whether to withdraw.

$t = 2$:

- The bank allocates the remaining resources to depositors who have not withdrawn in period 1.

The postdeposit game starts after depositors make deposits at the bank. An individual depositor decides when to withdraw. A bank run occurs if at least one patient depositor withdraws. Knowing what depositors will do in the postdeposit game, a representative bank offers a contract that maximizes the ex ante expected utility of the depositors. Depositors determine whether to deposit at the bank or stay in autarky. Starting at $t = 0$, the entire game is called the predeposit game. Solving the model backward, as in Peck and Shell (2003), requires starting with the postdeposit game and describing the equilibrium given a contract. Then the predeposit game is completed by comparing the expected utilities in autarky with those in a banking economy.

THE POSTDEPOSIT GAME

The equilibrium concept is a perfect Bayesian equilibrium in which the strategies of the depositors are optimal given the depositors' beliefs about investment returns and the beliefs are updated by Bayes' rule whenever possible.

Let x_n^i and p_n^i denote the strategy and posterior belief that the return is high, respectively, of depositor i at stage n. Given each depositor's preferences and the structure of the game, depositor 1's strategy at stage 1 is

$$x_1^1 = 1 \text{ if impatient and } x_1^1 = 1 \text{ with probability } \theta_{S_1}^1 \text{ if patient,}$$

and depositor 2's strategy at stage 2 is

$$x_2^2 = 1 \text{ if impatient and } x_2^2 = 1 \text{ with probability } \theta_{x_1,S_2}^2 \text{ if patient.}$$

Since depositors can make withdrawals only at their informed stage, $x_n^i = 0$ when $n \neq i$.

Bayesian Updates

Suppose a depositor has prior belief p at the beginning of a stage. Let $\rho(p) \equiv pq + (1-p)(1-q)$ be the probability that an informed depositor will receive a favorable signal at that stage given the prior belief. When a depositor receives the signal, he updates his belief according to Bayes' rule:

$$(4)\qquad p_i^i(p)=\begin{cases} P_H(p)=\dfrac{pq}{\rho(p)}, & \text{if } S_i=H, \\ P_L(p)=\dfrac{p(1-q)}{1-\rho(p)}, & \text{if } S_i=L. \end{cases}$$

As the signal is accurate with probability $q \geq 0.5$, we have $P_H(p) \geq p \geq P_L(p)$, where the equality holds if and only if $q = 0.5$. That is, if a favorable signal is received, a depositor is more confident in the portfolio returns, whereas if an unfavorable signal is received, he is less confident.

If a depositor is not informed at a stage, he still learns some information by observing the informed depositor's action. When depositor 1 makes a decision at stage 1, his decision carries noisy information about the signals he has received. Given depositor 1's strategy, depositor 2's posterior belief at stage 1 is

$$(5)\qquad p_1^2(p)=\begin{cases} P_{\tilde{H}}(p)=\dfrac{p\left[\left(1-\theta_L^1\right)(1-q)+\left(1-\theta_H^1\right)q\right]}{\left(1-\theta_L^1\right)\left[1-\rho(p)\right]+\left(1-\theta_H^1\right)\rho(p)}, \\ \qquad \text{if depositor 1 waits;} \\ P_{\tilde{L}}(p)=\dfrac{p\left[\alpha+(1-\alpha)\left(\theta_L^1(1-q)+\theta_H^1 q\right)\right]}{\alpha+(1-\alpha)\left\{\theta_L^1\left[1-\rho(p)\right]+\theta_H^1\rho(p)\right\}}, \\ \qquad \text{if depositor 1 withdraws.} \end{cases}$$

The denominator of $P_{\tilde{H}}(p)$ is the probability that depositor 1 waits given depositor 1's strategies $\theta_{S_1}^1$. The numerator is the probability that the bank's portfolio return is high and depositor 1 waits. The same rule applies for $P_{\tilde{L}}(p)$.

After depositor 2 makes his decision, depositor 1 updates his belief (although he has no chance to change his decision) in a similar way, as follows:

$$(6)\qquad p_2^1(p)=\begin{cases} P_{x_1,\tilde{H}}(p)=\dfrac{p\left[\left(1-\theta_{x_1,L}^2\right)(1-q)+\left(1-\theta_{x_1,H}^2\right)q\right]}{\left(1-\theta_{x_1,L}^2\right)\left[1-\rho(p)\right]+\left(1-\theta_{x_1,H}^2\right)\rho(p)}, \\ \qquad \text{if depositor 2 waits;} \\ P_{x_1,\tilde{L}}(p)=\dfrac{p\left[\alpha+(1-\alpha)\left(\theta_{x_1,L}^2(1-q)+\theta_{x_1,H}^2 q\right)\right]}{\alpha+(1-\alpha)\left\{\theta_{x_1,L}^2\left[1-\rho(p)\right]+\theta_{x_1,H}^2\rho(p)\right\}}, \\ \qquad \text{if depositor 2 withdraws.} \end{cases}$$

Again, the denominator of $P_{x_1,\tilde{H}}(p)$ is the probability that depositor 2 waits given depositor 2's strategies $\theta^2_{x_1,S_2}$. The numerator is the probability that the bank's portfolio return is high and depositor 2 waits. The same rule applies for $P_{x_1,\tilde{L}}(p)$.

Strategies

The equilibrium strategies are a vector of $\theta = (\theta^1_{S_1}, \theta^2_{x_1,S_2})$, $x_1 = 0,1$, and $S_1, S_2 = L, H$ that solves the depositor's expected utility maximization problem at each node. Working backward, depositor 2, if patient, chooses the withdrawal probability $\theta^2_{x_1,S_2}$ to maximize his expected utility given his observation of depositor 1's action and his own private signal:

(7)
$$\hat{w}^2(x_1,S_2) = \max_{\theta^2_{x_1,S_2}\in[0,1]} \theta^2_{x_1,S_2} u\left(c^1(x_1,1)\right) + \left(1-\theta^2_{x_1,S_2}\right)\left[p_2^2 u\left(c^2\left(x_1,0,\overline{R}\right)\right) + \left(1-p_2^2\right)u\left(c^2\left(x_1,0,\underline{R}\right)\right)\right],$$

where $p_2^2 = P_{S_2}\left(P_{\tilde{L}}(p_0)\right)$ if $x_1 = 1$ and $p_2^2 = P_{S_2}\left(P_{\tilde{H}}(p_0)\right)$ otherwise. The first term on the right-hand side is the payoff if he withdraws given depositor 1's action. The second term in the closed bracket is the expected utility if he waits.

For depositor 1, if he does not withdraw at stage 1, his expected utility at the end of stage 2 is

(8)
$$\hat{w}^1(0,x_2,S_1) = p_2^1 u\left(c^2\left(0,x_2,\overline{R}\right)\right) + \left(1-p_2^1\right)u\left(c^2\left(0,x_2,\underline{R}\right)\right),$$

where $p_2^1 = P_{0,\tilde{L}}\left(P_{S_1}(p_0)\right)$ if $x_2 = 1$ and $p_2^1 = P_{0,\tilde{H}}\left(P_{S_1}(p_0)\right)$ otherwise. At stage 1, depositor 1 chooses withdrawal probability $\theta^1_{S_1}$ to maximize his expected utility given the probability that depositor 2 will withdraw (i.e., the probability that 1 reaches $\hat{w}^1(0,1,S_1)$). This probability, in turn, is partially determined by depositor 1's action, as depositor 2 updates his belief according to what he observes. Depositor 1 solves

(9)
$$\hat{w}^1(S_1) = \max_{\theta^1_{S_1}\in[0,1]} \theta^1_{S_1} u\left(c^1(1)\right) + \left(1-\theta^1_{S_1}\right)\left\{\begin{array}{l}\left[\alpha + (1-\alpha)\left(\theta^2_{0,H}\rho\left(P_{S_1}(p_0)\right) + \theta^2_{0,L}\left(1-\rho\left(P_{S_1}(p_0)\right)\right)\right)\right]\hat{w}^1(0,1,S_1) + \\ (1-\alpha)\left[\left(1-\theta^2_{0,H}\right)\rho\left(P_{S_1}(p_0)\right) + \left(1-\theta^2_{0,L}\right)\left(1-\rho\left(P_{S_1}(p_0)\right)\right)\right]\hat{w}^1(0,0,S_1)\end{array}\right\},$$

where the multipliers in front of $\hat{w}^1(0,1,S_1)$ and $\hat{w}^1(0,0,S_1)$ are the probabilities that depositor 2 withdraws/waits given that depositor 1 receives S_1 and withdraws.

In equilibrium, depositor 2 infers the investment status by watching depositor 1's action. His belief is updated by his private signal and depositor 1's action. When depositor 1 makes a decision, he also knows his decision will affect depositor 2's belief and decision and, thus, his own payoff.

Table 1

Example of a History-Dependent Contract

Payments to depositors	Variables	Amount
Depositor 1 at $t = 1$	c^1 (1)	0.9998
Depositor 2 at $t = 1$ if 1 withdraws	c^1 (1,1)	1.0002
Depositor 2 at $t = 1$ if 1 waits	c^1 (0,1)	1.0000
Both depositors at $t = 2$ if both wait and $R = \bar{R}$	c^2 (0,0,$\bar{R}$)	1.0000
Depositor 1 at $t = 2$ if depositor 2 withdraws and $R = \bar{R}$	c^2 (0,1,$\bar{R}$)	1.0001
Depositor 2 at $t = 2$ if depositor 1 withdraws and $R = \bar{R}$	c^2 (1,0,$\bar{R}$)	1.0002
Both depositors at $t = 2$ if both wait and $R = \underline{R}$	c^2 (0,0,$\underline{R}$)	1.0000
Depositor 1 at $t = 2$ if depositor 2 withdraws and $R = \underline{R}$	c^2 (0,1,$\underline{R}$)	0.9997
Depositor 2 at $t = 2$ if depositor 1 withdraws and $R = \underline{R}$	c^2 (1,0,$\underline{R}$)	1.0002

The solution to maximization problems (7)-(9) given a contract is not necessarily unique. A simple way to illustrate the properties of equilibria is to construct some numerical examples. In all examples in the paper, the utility function is $u(c) = \frac{(c+b)^{\gamma} - b^{\gamma}}{1-\gamma}$, where $b = 0.01$ and $\gamma = 1.5$. The parameter $b > 0$ ensures that marginal utility is bounded low by a positive number when $c = 0$. Example 1 shows a case in which a contract has more than one perfect Bayesian equilibrium.

Example 1: Multiple equilibria in the postdeposit game. The parameters in the economy are $\alpha = 0.5$, $\bar{R} = 1.3$, $\underline{R} = 0.1$, $p_0 = 0.5$, and $q = 0.7$. Table 1 shows the history-dependent contract considered here.

The contract in the example satisfies the resource constraints (1)-(3). That is, it is a feasible contract but it is not necessarily the best contract that a bank can offer. This contract has two pure strategy perfect Bayesian equilibria. They are

(Equilibrium 1) $\left(\theta_L^1 = 0,\ \theta_H^1 = 0,\ \theta_{1,L}^2 = 1,\ \theta_{0,L}^2 = 1,\ \theta_{1,H}^2 = 0,\ \theta_{0,H}^2 = 0\right)$, and

(Equilibrium 2) $\left(\theta_L^1 = 1,\ \theta_H^1 = 0,\ \theta_{1,L}^2 = 1,\ \theta_{0,L}^2 = 0,\ \theta_{1,H}^2 = 0,\ \theta_{0,H}^2 = 0\right)$.

In the first equilibrium, depositor 1's signal of investment return does not affect his decision. He always waits if he is patient. Depositor 2 cannot infer any information from depositor 1's action. Thus, depositor 2's decisions are based solely on his private signals, not the withdrawal history.

In the second equilibrium, depositor 1 reacts differently to different signals of investment return. His action partially reveals the signal he has received, which affects depositor 2's decision. Depositor 2's decision is dependent on the withdrawal history.

A banking contract is run proof if $\theta = 0$ is the unique solution. If a run-proof contract is provided, depositors do not withdraw unless they are impatient. All other contracts are called run-admitting, as these contracts admit at least one equilibrium in which at least one patient depositor withdraws based on some realization of private signals and withdrawal history.

THE PREDEPOSIT GAME

The ex ante expected utility of the depositors is determined by their strategies, which in turn are determined by the contract. Knowing the strategies of the depositors in the postdeposit game given a contract, the representative bank offers a contract that maximizes the ex ante expected utility of the depositors. Given the contract, depositors decide whether to stay in autarky or to deposit at the bank at $t = 0$. If the ex ante expected utility in autarky is higher than that under the banking contract, the contract will be accepted and the postdeposit game will be played. Otherwise, depositors prefer to stay in autarky.

Autarky

In autarky, depositors do not observe each other's actions. A depositor adjusts his investment portfolio after he receives private signals at $t = 1$. If the depositor is revealed to be impatient, he immediately consumes all of his available assets and receives utility $u(1)$. A patient depositor's expected utility in period 1 after receiving signal S is solved by

$$\hat{w}_1^{aut}(S) = \max_{\lambda_S \in [0,1]} P_S(p_0)u\left(\lambda_S + (1-\lambda_S)\overline{R}\right) + \left(1 - P_S(p_0)\right)u\left(\lambda_S + (1-\lambda_S)\underline{R}\right),$$

where λ_S denotes the proportion of assets liquidated after receiving the signal.

The ex ante expected utility in autarky is the weighted average of the expected utility in period 1. That is,

$$w_0^{aut} = \alpha u(1) + (1-\alpha)\left[\rho(p_0)\hat{w}_1^{aut}(H) + \left(1-\rho(p_0)\right)\hat{w}_1^{aut}(L)\right].$$

The Optimal Bank Contract

The bank's optimal contract maximizes the depositor's ex ante expected utility. As each of the depositors has probability 1/2 of being the first to receive the signals and make a decision, a depositor's ex ante expected utility is the equally weighted expected utilities of depositors 1 and 2 at the beginning of period 1. Let $\hat{w}^2(x_1)$ be depositor 2's expected utility at the end of stage 1 given depositor 1's action. Specifically,

$$\hat{w}^2(0) = \alpha u\left(c^1(0,1)\right) + (1-\alpha)\left\{\rho\left(P_{\tilde{H}}(p_0)\right)\hat{w}^2(0,H) + \left[1-\rho\left(P_{\tilde{H}}(p_0)\right)\right]\hat{w}^2(0,L)\right\}, \tag{10}$$

$$\hat{w}^2(1) = \alpha u\left(c^1(1,1)\right) + (1-\alpha)\left\{\rho\left(P_{\tilde{L}}(p_0)\right)\hat{w}^2(1,H) + \left[1-\rho\left(P_{\tilde{L}}(p_0)\right)\right]\hat{w}^2(1,L)\right\}. \tag{11}$$

The depositor's ex ante expected utility is given by

$$\begin{aligned} w_0 = {} & \frac{1}{2}\left\{\alpha u\left(c^1(1)\right) + (1-\alpha)\left[\rho(p_0)\hat{w}^1(H) + \left(1-\rho(p_0)\right)\hat{w}^1(L)\right]\right\} \\ & + \frac{1}{2}\left\{\begin{array}{c} (1-\alpha)\left[\rho(p_0)\left(1-\theta_H^1\right) + \left(1-\rho(p_0)\right)\left(1-\theta_L^1\right)\right]\hat{w}^2(0) + \\ \left[\alpha + (1-\alpha)\left[\rho(p_0)\theta_H^1 + \left(1-\rho(p_0)\right)\theta_L^1\right]\right]\hat{w}^2(1) \end{array}\right\}, \end{aligned} \tag{12}$$

Table 2

Example of an Optimal Run-Admitting Contract

$\hat{\omega}_0$	$c^1(1)$	$c^1(1,1)$	$c^2(1,0,\bar{R})$	$c^2(1,0,\bar{R})$
18.0546	1.0064	0.9936	1.1924	0.7949
$c^1(0,1)$	$c^2(0,1,\bar{R})$	$c^2(0,1,\underline{R})$	$c^2(0,0,\underline{R})$	$c^2(0,0,\bar{R})$
1.0296	1.1644	0.7763	0.8000	1.2000

where the multipliers in front of $\hat{w}^2(0)$ and $\hat{w}^2(1)$ are the ex ante probabilities that depositor 1 will wait or withdraw.

The representative bank offers a feasible contract that maximizes the ex ante expected utility of the depositors. That is, the bank seeks $c = (c^1(1), c^1(x_1,1), c^2(x_1,x_2,R))$ to solve

$$\hat{w}_0 = \max_c w_0$$
$$\text{st (1)-(3).}$$

The optimal contract will be accepted at $t = 0$ if and only if $\hat{w}_0 \geq w_0^{aut}$. The analytical solution to the optimal contract is complicated to solve, so numerical examples are used to illustrate the properties of a pure strategy equilibrium under an optimal banking contract. As demonstrated in the previous section, one of the challenges is the multiplicity of equilibria in the postdeposit game. Unfortunately, the conditions for the uniqueness of the equilibrium are too complicated to derive. In the following examples, we check numerically that the optimal contract allows for a unique equilibrium in the postdeposit game.[13,14] Examples 2 and 3 illustrate two different cases of an optimal contract; one is run admitting and the other is run proof.

Example 2: The optimal banking contract is run admitting. Parameters in this example are $\alpha = 0.6$, $\bar{R} = 1.2$, $\underline{R} = 0.8$, $p_0 = 0.75$, and $q = 0.9$. Table 2 describes the payment scheme that an optimal bank contract provides.

Given this contract, the equilibrium strategies of depositors in the postdeposit game, if patient, are $\theta_L^1 = 1$, $\theta_H^1 = 0$, $\theta_{1,L}^2 = 1$, $\theta_{0,L}^2 = 0$, $\theta_{1,H}^2 = 0$, and $\theta_{0,H}^2 = 0$. Given the equilibrium strategies, we can calculate the probability of bank runs. Some bank runs are partial—only one of the depositors withdraws but he does not need to consume immediately; some are full bank runs—both depositors withdraw regardless of their consumption types. The probability of having a partial run conducted by depositor 1 in this example is $\Pr(1 \text{ is patient})\Pr(S_1 = L)\Pr(2 \text{ is impatient or } S_2 = H) = 0.0864$. The partial run conducted by depositor 2 happens with probability $\Pr(1 \text{ is impatient and } 2 \text{ is patient})\Pr(S_2 = L) = 0.072$. The probability of a full bank run is $\Pr(1 \text{ and } 2 \text{ are patient})\Pr(S_1 = S_2 = L) = 0.0336$.

We also report the strategies of a depositor in autarky and compare the welfare in autarky with that under the optimal contract. In autarky, a depositor leaves all assets invested if a favorable signal is received and liquidates all assets when an unfavorable signal is received. The consumption of a depositor contingent on the signals and the return is summarized as follows: $\{c_1 = 1, c_2(H,\bar{R}) = 1.2, c_2(H,\underline{R}) = 0.8, c_2(L,\bar{R}) = 1, \text{ and } c_2(L,\underline{R}) = 1\}$. The ex ante expected utility in autarky, w_0^{aut}, is 18.0540, which is lower than $\hat{w}_0$. Hence, the contract will be accepted, although bank runs will take place with positive probability.

Table 3

Example of a Run-Proof Contract

$\hat{\omega}_0$	c^1 (1)	c^1 (1,1)	c^2 (1,0,$\bar{R}$)	c^2 (1,0,$\underline{R}$)
18.0383	1.0053	0.9947	1.1936	0.7957
c^1 (0,1)	c^2 (1,0,$\bar{R}$)	c^2 (1,0,$\underline{R}$)	c^2 (0,0,$\bar{R}$)	c^2 (0,0,$\underline{R}$)
1.0116	1.1861	0.7907	0.2000	1.8000

The signals are 90 percent accurate in this example. In autarky, since the signal is highly accurate, a depositor will follow the signal. In the banking economy, a private signal still plays an important role—depositor 1 follows the signal as he would in autarky since he must make decisions before he learns information from depositor 2. However, depositor 2 infers information from depositor 1's action and depositor 2 does not rely solely on his private signals to make a withdrawal decision. Depositor 1's decision to wait reveals that a favorable signal has been received. If depositor 2 receives an unfavorable signal, it will be offset by the favorable signal inferred and his posterior belief will become p_0. As p_0 still is fairly favorable, depositor 2 will not withdraw. If depositor 1 withdraws, however, the action sends noisy information that an unfavorable signal may be received. When depositor 2 receives an unfavorable signal, his belief is lowered even more, such that he prefers to liquidate the asset immediately to mitigate the loss in investment. But if depositor 2 gets a favorable signal, his posterior belief becomes higher than p_0. In this case, he still follows his private signal and waits.

A run-admitting bank contract is optimal in some economies for the following reasons. First, the contract helps smooth the consumption in an economy with aggregate consumption shocks. Second, in an economy with production uncertainty, a bank run is not necessarily bad. In example 2, if the true state of productivity is low, then depositors receive payments in the amount of either 1.0064 or 0.9936. But if both depositors wait, each will get 0.8000. A bank run is a means to terminate low-quality investments to mitigate future losses. In this sense, information about investment return is valuable and a run-admitting contract allows information to be partially revealed.

In example 2, the partial run conducted by depositor 2 relies on the fact that depositor 1 withdraws. Because of imperfect signals and the revelation of imperfect information by actions, a bank run can occur when productivity is actually high. If the probability of a bank run in a high-return state is too high, a run-proof contract will be offered by the bank. Example 3 illustrates this precise case. When the signal received by depositors contains too much noise, a run-proof contract is optimal.

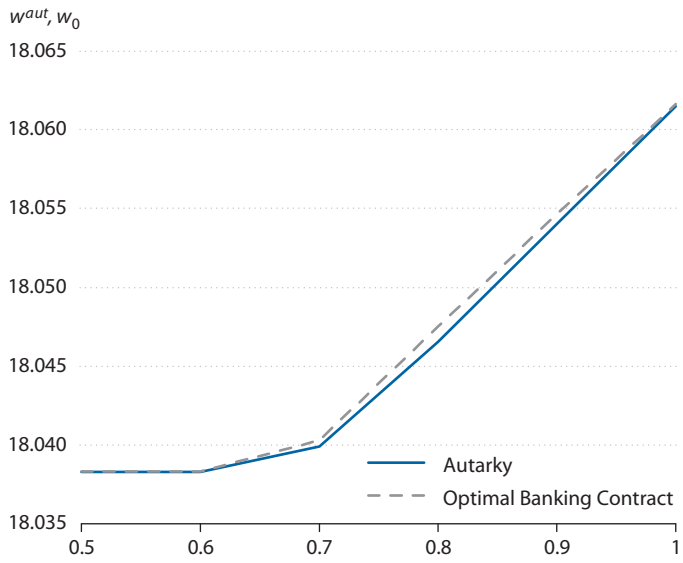
Example 3: The optimal banking contract is run proof. The parameters in this economy are the same as in example 2 except that $q = 0.5$. In this case, a productivity signal is not informative. Table 3 describes the payment scheme of the optimal banking contract.

Given such a contract, there is a unique equilibrium in the postdeposit game in which depositors withdraw if and only if they are impatient.

In autarky, depositors leave all assets invested if they are patient. The private signal does not carry any information and if a depositor decides to invest ex ante, he will not change his decision if he is patient, as no useful information arrives ex post. The ex ante expected utility in autarky

Figure 1

Expected Utilities in Autarky and Under an Optimal Deposit Contract



is 18.0383, which is equivalent to that in the banking economy. Depositors weakly prefer to accept the contract and no bank run occurs ex post. Because the signals carry too much noise in a banking economy, if a run-admitting contract were provided, bank runs would happen too often when the fundamentals are strong. Therefore, a contract that does not allow for the disclosure of information is more desirable here. Compared with example 2, the contract here provides less consumption to the first depositor who withdraws in $t = 1$ (i.e., $c^1(1)$ and $c^1(0,1)$). The lower payments in $t = 1$ discourage depositors from withdrawing even when they receive unfavorable signals (although signals are not useful in predicting returns in this case). On the contrary, payments of $c^1(1)$ and $c^1(0,1)$ in example 2 are higher, so depositors are more encouraged to withdraw when the signals are unfavorable. As a result, depositors partially reveal their signals by their actions.

Figure 1 plots the expected utilities in autarky and under the optimal contract with different values of q given other parameters in example 2.[15] The dashed line represents the expected utility under the optimal banking contract, whereas the solid line represents the expected utility in autarky.

When q is small, the contract is run proof and the expected utility is the same as in autarky. As q increases, the optimal banking contract is run admitting and yields strictly higher expected utility than autarky. The difference in expected utilities between a banking economy and autarky is not monotone: As q approaches 1, the welfare gain in the banking economy decreases ($w^{aut} = 18.0615$ and $\hat{w}_0 = 18.0616$ if $q = 1$). Why is that? In our model, depositors gain from participating in banking through two functions of the bank. First, the bank provides consumption insurance for depositors as noted in the literature (see, for example, Diamond and Dybvig, 1983). Second, the bank provides additional information on fundamentals to depositors since with-

Table 4

Example of an Optimal Contract When Investment Return Signals Are Public

$c^1(1,H)$	$c^1(1,L)$	$c^1(1,1,H,S_2)$	$c^1(1,1,L,S_2)$
1.0084	0.9990	0.9916	1.0010
$c^1(0,1,H,H)$	$c^1(0,1,H,L)$	$c^1(0,1,L,H)$	$c^1(0,1,L,L)$
1.0271	1.0106	1.0106	0.9984
$c^2(1,0,H,H,\bar{R})$	$c^2(1,0,H,H,\underline{R})$	$c^2(1,0,H,L,\bar{R})$	$c^2(1,0,H,L,\underline{R})$
1.1899	0.7933	1.1899	0.7933
$c^2(1,0,L,H,\bar{R})$	$c^2(1,0,L,H,\underline{R})$	$c^2(1,0,L,L,\bar{R})$	$c^2(1,0,L,L,\underline{R})$
1.2012	0.8008	1.0010	1.0010
$c^2(0,0,H,H,\bar{R})$	$c^2(0,0,H,H,\underline{R})$	$c^2(0,0,H,L,\bar{R})$	$c^2(0,0,H,L,\underline{R})$
1.2000	0.8000	1.2000	0.8000
$c^2(0,0,L,H,\bar{R})$	$c^2(0,0,L,H,\underline{R})$	$c^2(0,0,L,L,\bar{R})$	$c^2(0,0,L,L,\underline{R})$
1.2000	0.8000	1	1
$c^2(0,1,H,H,\bar{R})$	$c^2(0,1,H,H,\underline{R})$	$c^2(0,1,H,L,\bar{R})$	$c^2(0,1,H,L,\underline{R})$
1.1675	0.7784	1.1873	0.7915
$c^2(0,1,L,H,\bar{R})$	$c^2(0,1,L,H,\underline{R})$	$c^2(0,1,L,L,\bar{R})$	$c^2(0,1,L,L,\underline{R})$
1.1873	0.7915	1.0016	1.0016

drawals are publicly observable. In autarky, depositors observe only their own signals. When $q = 1$ (i.e., signals are perfect), observing the other depositors' actions does not provide additional information. Therefore, the gain from information aggregation disappears in this extreme case.

PUBLIC SIGNALS

To illustrate that the economy is inefficient because the information on investment is private, it is useful to solve a numerical example with public signals on portfolio returns and compare it with an example with private signals. Here we continue with example 2 but with the conditions that the signals on investment return are now publicly observable, although consumption signals are private.

Example 4: Public signals on investment return. In this example, the signals on investment return are publicly observable. Depositors have private information about their consumption types. The contract specifies the payments contingent on a depositor's arrival time, the withdrawal history, and the public signals. The parameters are the same as in example 2. Table 4 shows the optimal payment scheme. The expected utility under the optimal payment scheme is $\hat{w}_0^* = 18.0567$, which is higher than that in the economy with private investment return signals.

The strategies of depositors under the optimal contract are $\theta = 0$. That is, no patient depositor withdraws. The optimal payment scheme given public information encourages depositors to truthfully report their consumption types by their actions. Given any public history, the expected utility of a depositor in the last period is higher than the utility from immediate withdrawal. Although there are two sources of uncertainties in our model, the bank and depositors share the same information regarding investment return. In other words, the only information

asymmetry between the bank and the depositors comes from consumption types. Now the bank's only requirement is to design an incentive-compatible contract to eliminate bank runs. Similar to Green and Lin's (2000, 2003) findings, a contract contingent on the withdrawal history can prevent bank runs by eliminating the asymmetric information between the bank and depositors.

Another lesson from this example is that the direct revelation rule is, in general, not incentive compatible in the environment with private signals of investment return. Suppose that depositors must announce their private signals (direct revelation) before they make decisions at $t = 1$. Depositors have incentives to lie (violate incentive compatibility) to the bank when they receive an unfavorable signal. A depositor can instead tell the bank that although he has received a favorable signal, he needs to consume immediately. If the bank believes him, he could receive a larger payment than he should. Example 4 illustrates this point. Suppose depositor 1 is patient. He receives an unfavorable signal and he reports truthfully. Depositor 2 is also patient and he also receives an unfavorable signal. If he reveals the true signal and does not withdraw at $t = 1$, he will receive $c^2(0,0,L,L,\bar{R}) = c^2(0,0,L,L,\underline{R}) = 1.0016$ in the last period, whereas if he claims to be impatient but has received a favorable signal, he will receive $c^1(0,1,L,H) = 1.0106$.

CONCLUSION

This paper provides a simple model to understand the dynamics during bank runs in an environment in which depositors have private information on bank fundamentals and the deposit contract can be made contingent on withdrawal history. Given such a contract, there is a perfect Bayesian equilibrium in which depositors' beliefs and actions are affected by the actions of others. Under certain parameterizations, the computed examples indicate that the optimal bank contract tolerates bank runs. Runs are tolerated because they are triggered by unfavorable signals on bank portfolios and liquidating unsuccessful investments early can prevent future losses. Because the signals are private, a depositor's action is the only way to partially reveal his private information. A run-admitting contract allows information to be revealed.

Nevertheless, if signals are too noisy, bank runs may occur too often when fundamentals are strong. In this case, the bank would offer a run-proof contract. Given the relevant role of information, a policy that can make private information public would be useful to improve the welfare and eliminate bank runs.

One of the model's main limitations is that the bank has no information on investment. A more sophisticated model in which the bank receives signals on investment would prompt more interesting questions, such as how to eliminate a bank's moral hazard incentives related to the information asymmetry between the bank and its depositors and how the bank can reduce the probability of bank runs resulting from incorrect signals.

NOTES

1 See Allen and Gale (1994), Goldstein and Pauzner (2005), and Gu (2011).

2 The sunspot signals can be viewed as the uncertainty in the fundamentals taken to the limit (as in Manuelli and Peck, 1992).

[3] Brunnermeier (2001, p. 214) says that "Although withdrawals by deposit holders occur sequentially in reality, the literature typically models bank runs as a simultaneous move game."

[4] Special finance houses are like commercial banks, but their deposits are not insured.

[5] Also see Schumacher (2000) for details on the 1994-95 Argentine banking crisis.

[6] Bank runs here have the features of the herd effect (Banerjee, 1992, and Bikhchandani, Hirshleifer, and Welch, 1992).

[7] Unlike Green and Lin (2000, 2003), the asymmetric information between the bank and depositors cannot be fully eliminated by depositors' simple zero-one (i.e., withdrawal-or-wait) decisions.

[8] See Anderson (2009) for pricing risk.

[9] This result agrees with the findings of Green and Lin (2000, 2003) and Andolfatto, Nosal, and Wallace (2007) that the payment schedules contingent on withdrawal history can eliminate bank runs in an economy with i.i.d. consumption shocks.

[10] Besides the additional dimension of uncertainty, there are two other distinctions between Green and Lin's (2000, 2003) setup and ours. First, Green and Lin use a direct revelation mechanism in which depositors report their private information about consumption types to the bank. The direct revelation mechanism is not feasible in an economy with two dimensions of uncertainty—the bank makes a bigger payment if the future return is higher. So a depositor would always report that he receives a favorable signal on the bank's portfolio when he decides to withdraw. Second, depositors do not observe the decisions of others in Green and Lin's economy but they do in ours. Whether a decision is observable is not crucial to Green and Lin's model (see Andolfatto, Nosal, and Wallace, 2007). However, it is crucial in our model because the observed withdrawals provide information on fundamentals.

[11] In a similar model setup, Gu (2011) studies the herding effect on bank runs given a simple demand deposit contract.

[12] The consideration of a payment scheme contingent on history has been widely discussed in the banking literature. See Diamond and Dybvig (1983) for details on full suspension of convertibility in an economy with no aggregate uncertainty and Wallace (1990) for partial suspension of convertibility. Green and Lin (2000, 2003) show that in a finite economy with i.i.d. consumption shocks, the optimal banking contract that pays depositors depending on their arrival time and the withdrawal history can completely eliminate panic-based bank runs.

[13] Only pure strategy equilibria are considered. The expected utility under a true optimal contract (that is, if we consider a mixed strategy equilibrium) can be higher. However, considering mixed strategies significantly complicates computation. Note that the strategies under a run-proof contract are pure strategies. Hence, the bottom line is that the optimal contract is not run proof in some economies (example 2), while it is optimal in others (example 3).

[14] We check the uniqueness in the following way: There are 27 possible pure strategy profiles. We compute the bank's optimal contract given each strategy profile and then check whether the given strategy profile is the equilibrium strategy under the computed optimal contract. And if so, whether the ex ante expected utility is higher than that under autarky. In all the numeric examples in the paper, only one of the 27 cases is the equilibrium strategy and yields ex ante expected utility higher than the autarky. Hence, it is sufficient to conclude the optimal contract allows for a unique equilibrium.

[15] Again, only pure strategy equilibria are considered. The bottom line is that when q increases, the optimal contract is no longer run proof.

REFERENCES

Allen, Franklin, and Gale, Douglas. "Limited Market Participation and Volatility of Asset Prices." *American Economic Review*, September 1994, *84*(4), pp. 933-55.

Anderson, Richard G. "Bagehot on the Financial Crises of 1825...and 2008." Federal Reserve Bank of St. Louis *Monetary Trends*, February 2009; http://research.stlouisfed.org/publications/mt/20090201/cover.pdf.

Anderson, Richard G. and Gascon, Charles G. "The Commercial Paper Market, the Fed, and the 2007-2009 Financial Crisis." Federal Reserve Bank of St. Louis *Review*, November/December 2009, *91*(6), pp. 589-612; http://research.stlouisfed.org/publications/review/article/7857.

Andolfatto, David; Nosal, Ed and Wallace, Neil. "The Role of Independence in the Diamond-Dybvig Green-Lin Model." *Journal of Economic Theory*, November 2007, *137*(1), pp. 709-15.

Banerjee, Abhijit V. "A Simple Model of Herd Behavior." *Quarterly Journal of Economics*, August 1992, *107*(3), pp. 797-817.

Bikhchandani, Sushil; Hirshleifer, David and Welch, Ivo. "A Theory of Fads, Fashion, Custom, and Cultural Change as Informational Cascades." *Journal of Political Economy*, October 1992, *100*(5), pp. 992-1026.

Brunnermeier, Markus. *Asset Pricing under Asymmetric Information-Bubbles, Crashes, Technical Analysis, and Herding*. Oxford, UK: Oxford University Press, 2001.

Diamond, Douglas and Dybvig, Philip. "Bank Runs, Deposit Insurance, and Liquidity." *Journal of Political Economy*, June 1983, *91*(3), pp. 401-19.

Goldstein, Itay and Pauzner, Ady. "Demand-Deposit Contracts and the Probability of Bank Runs." *Journal of Finance*, June 2005, *60*(3), pp. 1293-327.

Gorton, Gary. *Slapped by the Invisible Hand: The Panic of 2007*. New York: Oxford University Press, 2010.

Green, Edward J. and Lin, Ping. "Diamond and Dybvig's Classic Theory of Financial Intermediation: What's Missing?" Federal Reserve Bank of Minneapolis *Quarterly Review*, Winter 2000, *24*(1), pp. 3-13; www.minneapolisfed.org/research/qr/qr2411.pdf.

Green, Edward J. and Lin, Ping. "Implementing Efficient Allocations in a Model of Financial Intermediation." *Journal of Economic Theory*, March 2003, *109*(1), pp. 1-23.

Gu, Chao. "Herding and Bank Runs." *Journal of Economic Theory*, January 2011, *146*(1), pp. 163-88.

Manuelli, Rodolfo and Peck, James. "Sunspot-like Effects of Random Endowments." *Journal of Economic Dynamics and Control*, April 1992, *16*(1), pp. 193-206.

Peck, James and Shell, Karl. "Equilibrium Bank Runs." *Journal of Political Economy*, February 2003, *111*(1), pp. 103-23.

Schumacher, Liliana. "Bank Runs and Currency Run in a System without a Safety Net: Argentina and the 'Tequila' Shock." *Journal of Monetary Economics*, August 2000, *46*(1), pp. 257-77.

Starr, Martha and Yilmaz, Rasim. "Bank Runs in Emerging-Market Economies: Evidence from Turkey's Special Finance Houses." *Southern Economic Journal*, April 2007, *73*(4), pp. 1112-132.

Wallace, Neil. "A Banking Model in Which Partial Suspension Is Best." Federal Reserve Bank of Minneapolis *Quarterly Review*, Fall 1990, *14*(4), pp. 3-16; www.minneapolisfed.org/research/qr/qr1442.pdf.

Close

Carlos Garriga

Research officer and economist, Federal Reserve Bank of St. Louis

http://research.stlouisfed.org/econ/garriga/

Research Focus

Carlos Garriga's recent research has focused on house price movements, mortgage finance, and the macroeconomic implications of housing. Past research has analyzed the issues of optimal fiscal policy, the design of social security reforms, and the financing of education.

Chao Gu

Assistant professor of econonics, University of Missouri–Columbia

Research Focus

Chao Gu's research focuses on money, banking, and credit markets. Her research analyzes bank runs, credit market cycles, pricing in the payment system, and unconventional monetary policy.