CoBANK

OUTLOOK Economic Data and Commentary

April 2012 Volume 9 Number 4

The Coming Tech Boom

By most key measures, the U.S. economy is still struggling: GDP growth is lethargic, the housing market remains weak and unemployment rates are uncomfortably high.

But physicist-turned-technology consultant Mark Mills argues there is reason for optimism. In fact, Mills believes the pace of innovation in the world of high technology has brought us to the cusp of a transformational event in the nation's economic history, one that's on par with the automobile age or the advent of the telephone.

Mills, who is chief executive of the Digital Power Group, managing director of the Opportunities Development Group and a regular columnist for Forbes, connects investors and new technology companies primarily in the energy sector. While so many businesses and industries operate in silos, technology cuts across them all. The coming tech-boom, Mills says, will affect everything. And as it did with cars and telephones, such a revolution will drive profound cultural change and economic growth, in ways and amounts we can only begin to understand today.

OUTLOOK: You theorize that we're on the verge of a huge tech boom that will fuel the economy for decades to come. What's driving this technological transformation?

Mark Mills: It's the convergence of three huge trends: big data – in large part what we call 'the cloud' – smart manufacturing and the wireless revolution.

While big transformations have already occurred in technology and computing, we're now entering a radically new era because these technologies are not just more widespread but are becoming so powerful and so cheap they move us into a whole new realm.

It's helpful to look at analogies, like the automobile age. It's not as if someone invented a car around 1880 and everyone in the world started driving a car. At the beginning, it was a complicated piece of machinery, with thousands of parts, put together like a piece of jewelry. More than 40 years passed before Henry Ford perfected mass production, which resulted in lower costs, higher

quality and mass adoption. But not until the 1950s did the automobile begin to fundamentally transform America. The use of cars soared, giving rise to all manner of industries, including a huge vacation industry, and fueling our expansive highway system, which transformed the nation's landscape. It made the modern shopping mall possible, because you need the ubiquitous cheap car to get there. No one predicted any of it.

Telephony followed the same cycle. Very few people had a phone initially. Then everyone had one. That happened once it became cheap and ubiquitous. It too changed our social structure. With cell phones, it took several decades to go from the Gordon Gekko phones of the 1980s to today's smart phones. Such deep cultural and economic transformations come not from a single invention, but from a constellation of events over decades.

Big data is now starting to impact our economy and society in a major way because we have crossed an invisible line in the combination of a variety of terribly cheap, enormously powerful computing and communications devices.

OUTLOOK: What is big data, or the cloud, and what's so great about it?

MM: There's no standard definition for what we call "the cloud." It's a way of putting supercomputing power directly in the hands of individuals and businesses anywhere they need it, anytime, and inexpensively. For instance, when you use Google Maps you are asking your phone or computer to ask a computer somewhere else to figure out the map. That remote capability, to instantly create a specific map, resides in a data center the size of a warehouse. That data center is the cloud. Then your phone displays it, and keeps it updated.

The power of the cloud becomes significant with emerging applications of metadata analysis. Software firms are crunching astronomical quantities of data looking for patterns, as it relates to everything from buying habits and travel preferences to patterns in disease, financial markets, and manufacturing processes.

OUTLOOK: What types of innovation do you expect to see from all the data crunching?

MM: We can look at medicine. Diagnosing disease is one of the most difficult things. Metadata medicine would integrate many domains, including health facts and histories along with aspects of your current health-related information – what's around you and impacting your body, how your body is operating, and what your body looks like, mainly inside – and see patterns. Computers are on the verge of being able to do that.

About this article

Mark P. Mills is founder and president of the Digital Power Group, an energy-tech focused consultancy and capital advisory group, and a managing director with the Opportunities Development Group, a global strategic consultancy. He was formerly the co-founder and chief tech strategist for Digital Power Capital, a boutique venture fund, where in addition to serving on numerous boards, he served as chairman and CEO of a lithium battery start-up.

He writes the *Energy Intelligence* column for Forbes and is co-author of the book, "The Bottomless Well: The Twilight of Fuel, the Virtue of Waste, and Why We Will Never Run Out of Energy." His work has appeared in *The Wall Street Journal* and *New York Times Magazine*, and he has appeared on CNN, Fox News, CNBC, PBS, NBC and ABC and on *The Daily Show* with Jon Stewart.

Take the "Tricorder," a Star Trek-inspired cordless. The idea is to do in real life what we've seen in fiction: Wave it over the human body and it gathers information and images, even portable CAT-scan type images, about your immediate condition. Almost instantly, it combines that information with data in the cloud, information you've entered voluntarily about your diet, health history, medications and information known about similar conditions or problems. The Tricorder's wireless link to the cloud accesses the universe of medical literature to generate advice specific to you and your body. Now you have access to supercomputing power that only governments used 30 years ago.

OUTLOOK: When will such personal metadata analyses tools be available?

MM: I wouldn't be surprised to see something like the Tricorder in the very near future, perhaps in the next few years. Keep in mind that this is your access to your cloud, where your buying patterns, eating and travel patterns, medical records, reside. Perhaps you picked up a disease while traveling. Let's say the CDC (Centers for Disease Control and Prevention) has learned there was an outbreak of illness in the region you visited. That information is in the cloud. All of that is going to be personalized to you and be private and secure.

TOP CELL PHONE COUNTRIES

COUNTRY	NUMBER OF CELL PHONES	POPULATION	PERCENTAGE
China	1,010,000,000	1,341,000,000	75.32
India	903,727,208	1,210,193,422	74.89
United States	327,577,529	310,866,000	103.9
Indonesia	250,100,000	237,556,363	105.28
Brazil	245,200,000	192,379,287	127.45
Russia	224,260,000	142,905,200	154.5
Japan	121,246,700	127,628,095	95.1
Pakistan	114,610,000	178,854,781	66.5
Germany	107,000,000	81,882,342	130.1
Nigeria	90,583,306	140,000,000	64.7

Source: Various sources. Compiled by Wikipedia

OUTLOOK: How can we be assured that information remains private and secure?

MM: Cyber-security is one of the big, practical, even existential, challenges of this era. First, most people already trust very sensitive information to the cloud, such as banking information. It is remarkably secure, all things considered, and getting better. Second, technology itself is the solution to security. In many ways, your information is more secure in the cloud than sitting in file folders in some unlocked drawer in someone's office. As consumers we will have increasing choices about what we want to keep private. Those who don't want to participate in building a 'personal' cloud don't have to, but they'll forgo the economic and health benefits of metadata analysis.

OUTLOOK: How might a business use metadata analysis?

MM: Let's consider farming. A lot of farmers are already using the cloud to optimize when to sell. Farmers also care about weather, disease and blight, soil and the emergence of new products and pesticides. All these things they care about exist in different information storage silos. The cloud lets them cross domains, connecting in ways that are constructive and useful. As the connections and sophistication of computing algorithms get more powerful, your farm, and what you do and what other farmers are doing, gets linked into all these relevant but independent databases. Let's say there's blight overseas. The cloud will not only incorporate a forecasting model to tell you if or when the blight will show up in your area, but it will let you know if your specific crop is susceptible, what to do about it, identify a treatment specifically relevant to your seeds, your geography and soil, and take into account myriad factors you haven't heard of yet. Your cloud will proactively tell you about it and what you need to do – more or less at no cost.

Many companies already do this in certain domains. IBM has a clever ad about Italian fishermen trying to match supply with demand. Oftentimes the fishermen caught too many fish, so prices and margins declined. Now the fishing boats tap into the cloud in real time, which allows them to plug into the marketplace to determine when and where to come to port. IBM says the fishermen's time to market has decreased and their profits have increased. I believe it.

In manufacturing, all this data crunching allows a company to make a product more efficiently. It gives a consumer a better map. That's what it means for each person. We want a 'Google Map' for whatever the question is. Does that change the world? Of course it changes the world. In 1910 if you said someday everyone will have a driver's license and a car, no one would have imagined it would be affordable, even feasible.

> Think of Facebook as a symptom of the incredible power of the connections between the device in our hands and what resides in the cloud. And so it's transforming not just how we socialize, but also commerce.

OUTLOOK: Can everyone afford this technology?

MM: It needs to be affordable for anybody and everybody. We haven't quite crossed that line yet. Take today's amazing iPhone or Android. Ten years ago you couldn't produce a device that did what they do – at any price, but if you could it would have been $20,000 to $50,000. Now the iPhone is $600 (without a contract tied to it). These phones will keep getting cheaper. In 10 years, today's iPhone will be $50 and the newest one, $400. Once today's iPhone is that cheap, everybody will want it and have it.

However, with that increased use comes more traffic and we don't know how services will be priced. We do know more network capacity will need to be built. Internet traffic is increasingly dominated by video. That's why companies want to charge more for what they call data hogs. But here too, expect that streaming data will get cheaper and easier to deal with. Just as we didn't know in 1950 how the car would change America, we don't know the scope of what economies and markets and people will do with the computing and communication technology of the future.

OUTLOOK: What role do you see social networks playing in this trend?

MM: Think of Facebook as a symptom of the incredible power of the connections between the device in our hands and what resides in the cloud. And so it's transforming not just how we socialize, but also commerce. Facebook will be used increasingly as a way to facilitate commerce.

Go back to the car analogy. New markets developed that people couldn't expect. There was no such thing as car vacations or 'cruising the strip.' The broadband Internet with Facebook is the equivalent of the Saturday night cruise in the 1950s. Advertising revenue in social media already amounts to roughly $15 billion a year.

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OUTLOOK: Does bigger data mean bigger energy? How will the future of the cloud be affected by energy prices and the development of new energy sources?

MM: The cloud, by necessity, consumes a lot of electricity. Big data centers are preferentially built where electricity is cheap. They need to be close to the big fat optical fiber information backbones, and close to cheap power. A single data center can consume as much or more electricity as a steel mill, 24-7. Tens of thousands are being built all over the world. That trend is going to continue – more data centers, more electricity.

Right now most electricity comes from coal and natural gas. That said, the cloud and metadata analysis improve the efficacy and efficiency of production. Cloud-centric computing makes it easier to find energy resources – oil, coal, natural gas – and to mine, build, process and distribute those resources.

OUTLOOK: Will data centers become more energy efficient?

MM: Yes, but it is efficiency that makes modern computing and communications possible in the first place. Measured from 1950, the energy needed to make computations has improved ten trillion-fold. So that's exactly why so many more data-machines got built and why the total amount of electricity used to perform computations has increased 300-fold since then.

Without more energy-efficient logic engines, efficient data storage and communications, there would be no Google or iPhone. If it were the 1980s, one Google data center would consume more electricity than Manhattan.

The same thing happened with the car. Automobile engine efficiency improved 500 percent pound-for-pound from early years to the late 20th century. This enabled better, more featured, safer, heavier and more affordable cars. So demand went up, driving a 400-percent increase in transportation fuel use.

Automotive fuel growth is now flattening in the West as we finally see near-saturation levels in road-miles and cars-per-household. But we are a long way from saturation of either information devices, or of video 'trips' on the information highways.

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OUTLOOK: Tell us about smart manufacturing.

MM: Smart manufacturing is about efficiency and accuracy. It means we build the right kinds of products with the least amount of wasted material, in the right amounts, delivered to just the right places. The factory of the future will be increasingly dependent on software, most of it in the cloud.

And now we are entering an era where we will do computational manufacturing – where supercomputing power will allow engineers not only to make alloys or chemicals that are tailored to do a specific thing, but even create novel new materials that don't exist in nature. For instance, pharmaceutical companies will be increasingly able to tailor designer drugs to individuals.

Everybody eventually will have access to supercomputing power, not free but almost free. It's equivalent to the revolution in agriculture. There was a time we didn't think we could feed the world, produce enough grain. Now America produces 600 percent more food than a century ago. The manufacturing revolution will do as much for how we make things as did the agricultural revolution for how we grow things. One key piece of this is the advent of the 3D printer, bringing about a paradigm shift in manufacturing.

OUTLOOK: What is 3D printing?

MM: 3D printing is already a viable commercial business for niche markets, for things like specialized aviation parts or medical devices like knee joints or dental prosthetics. You can design a 3D image of something from scratch using a computer, or make a 3D scan of an object. The image is sent it to the 3D printer that contains bins of appropriate powdered materials – ceramic, metals or plastics. The computer directs lasers or electron beams to melt and fuse the powders. It's similar to how powdered ink is fired at a paper, but in this case the powder releases in three-dimensions. The part seems to appear out of thin air. When you fabricate a part from the ground up like this, instead of machining the old-fashioned way – where basically you carve a part out of a large block of metal – a lot of waste is eliminated. More importantly, you can design unusual and highly-customized components.

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OUTLOOK: Does the U.S. workforce possess the skills necessary to support these new technologies and the new industries and markets they will create?

MM: I am more optimistic about the broad state of U.S. education than many. While there is much to improve – and we have slipped by some measures – our universities remain impressive. The future is bullish, in particular for students who study difficult subjects. But this has always been the case. The new paradigm for our future creates jobs at many levels and domains. We are already short of skilled employees in technical trades, jobs that trade schools and community colleges used to train students for, and which I believe they will return to doing more broadly. History shows economic growth does provide opportunity across the spectrum. Some say this is yet another form of automation taking away jobs. We've seen this movie before. U.S. manufacturing output doubled in the last 30 years. But while the manufacturing labor force decreased, overall U.S. employment soared during that period. The recent Great Recession is a temporary sidetrack, a painful one, but one that technology will turn around.

OUTLOOK: Are we investing enough money as a society, privately and publicly, to fuel this transformation? What, if any, roadblocks could hinder the progress of this technology revolution?

MM: I'd like to see more private sector investment across the board, and less government investment. Overly intrusive government regulations designed to make investing safer or more "fair" are generally counterproductive, despite good intentions. In recent years, and not just with this administration, I fear we've swung too far over to command-and-control of investment markets – and that does hinder new technology and business development.

OUTLOOK: How soon will it be before these three domains of innovation – big data, wireless communications and smart manufacturing – help our economy recover from the downturn of the past few years?

MM: All three domains, and in particular in combination, are starting to have positive impacts on the U.S. economy, and are hugely positive for our future. But short-term economic recoveries don't usually come from long-run trends. They can provide a spark though. It's a spark we don't want to blow out

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inadvertently with an over-burdensome government. That said, the trends I'm describing are deep, long-run trends that promise a multi-decade boom for America.

OUTLOOK: So many areas of technology are advancing. Why are big data, wireless communications and smart manufacturing so significant vs. biotechnology, for example? And what ties these three areas together?

MM: Much of the technology progress in other areas is being enabled by, and in some cases is almost entirely a consequence of, the power of the compute-and-communicate technologies. This is substantially the case in biotech and in services. Much of Walmart's power comes from the sophistication of its information-centric supply-chain system.

Smart manufacturing should really be called "computational manufacturing." It is possible because of computing and metadata analysis. Big data and smart manufacturing reinforce each other. Better manufacturing means you can make cheaper, better computing devices, which in turn enable smarter, better manufacturing. It's a technologically 'virtuous circle.' Wireless is the communications component and that's key now because of its ubiquity and increasingly affordable cost.

Maybe we may have lost our capacity for amazement. But just think: An IBM 370 mainframe introduced in 1970 managed the blazing speed of one million instruction sets per second, or one MIPS. A modern tablet, an iPad, can process a thousand MIPS, and at 1/10,000th the cost of yesterday's mainframe. And in just one cloud data center, we pack in the equivalent of tens of thousands of such microprocessors. The progress only continues.

OUTLOOK: Which countries are leading the way in these areas? Will the United States be at a competitive advantage or disadvantage in these fields?

MM: The U.S. is the epicenter of this revolution. While other nations are doing important things, the future of the cloud and metadata analysis is anchored in America. People who worry that China is beating us remind me of those who were convinced in the 1980s that America should follow Japan and its government's grand plan to leapfrog the U.S. in big computing. The government experts in Japan, and here, too, had no idea that the PC revolution was coming.

OUTLOOK: What should the United States be doing or not doing from a public policy standpoint to hasten the advent of these exciting technologies?

MM: In general, the U.S. government should get out of the way. Government's role here is to ensure high-quality education and a high-quality skilled workforce, fund long-term basic research for the next revolution, minimize trying to guess who the winners and losers are in a commercial business, minimize regulatory and tax burdens, and to generally remove barriers to business formation and growth. The rest will follow. It did before. It will again.

The average American today is, in real terms, about 700 hundred percent wealthier than her great grandparent of 1912. In hindsight it may be obvious that the emerging technologies in 1912 made a long run of wealth growth inevitable. This was the dawn of broad-based electrification and telephony, the automobile age, the radio amplifier. Observers of that day knew those things were important, but their imaginations failed to grasp the scope of the transformation to follow.

Now in 2012, short-term economic conditions and presidential politics divert our attention, but we are again on the precipice of another comparable transformation and another great growth cycle. Of course the Internet is already huge. But so was the auto industry in 1950. America already made a lot of cars, and yet that sector grew enormously, literally driving the American economy. It may be 2012, but for big data, it's only 1950.

Interest Rates and Economic Indicators

The interest rate and economic data on this page were updated as of 03/31/12. They are intended to provide rate or cost indications only and are for notional amounts in excess of $5 million except for forward fixed rates.

KEY ECONOMIC INDICATORS

Gross Domestic Product (GDP) measures the change in total output of the U.S. economy. The Consumer Price Index (CPI) is a measure of consumer inflation. The federal funds rate is the rate charged by banks to one another on overnight funds. The target federal funds rate is set by the Federal Reserve as one of the tools of monetary policy. The interest rate on the 10-year U.S. Treasury Note is considered a reflection of the market's view of longer-term macroeconomic performance; the 2-year projection provides a view of more near-term economic performance.

ECONOMIC AND INTEREST RATE PROJECTIONS

Source: Insight Economics, LLC and Blue Chip Economic Indicators

			US Treasury Securities		
2012	**GDP**	**CPI**	**Funds**	**2-year**	**10-year**
Q1	2.10%	2.30%	0.09%	0.30%	2.00%
Q2	2.20%	2.00%	0.10%	0.30%	2.20%
Q3	2.40%	2.30%	0.13%	0.30%	2.30%
Q4	2.60%	2.10%	0.13%	0.40%	2.30%
2013	**GDP**	**CPI**	**Funds**	**2-year**	**10-year**
Q1	2.50%	2.10%	Forecast Extended through 2013 next month		

PROJECTIONS OF FUTURE INTEREST RATES

The table below reflects current market expectations about interest rates at given points in the future. Implied forward rates are the most commonly used measure of the outlook for interest rates. The forward rates listed are derived from the current interest rate curve using a mathematical formula to project future interest rate levels.

IMPLIED FORWARD SWAP RATES

Years Forward	3-month LIBOR	1-year Swap	3-year Swap	5-year Swap	7-year Swap	10-year Swap
Today	0.47%	0.50%	0.75%	1.25%	1.76%	2.27%
0.25	0.42%	0.50%	0.82%	1.37%	1.86%	2.35%
0.50	0.50%	0.55%	0.93%	1.49%	1.97%	2.43%
0.75	0.52%	0.60%	1.04%	1.61%	2.07%	2.51%
1.00	0.56%	0.66%	1.16%	1.74%	2.18%	2.60%
1.50	0.69%	0.83%	1.44%	2.00%	2.40%	2.77%
2.00	0.87%	1.08%	1.71%	2.25%	2.61%	2.92%
2.50	1.18%	1.43%	2.03%	2.50%	2.80%	3.07%
3.00	1.50%	1.77%	2.35%	2.75%	3.00%	3.23%
4.00	2.13%	2.32%	2.86%	3.13%	3.30%	3.45%
5.00	2.74%	2.94%	3.25%	3.42%	3.54%	3.63%

HEDGING THE COST OF FUTURE LOANS

A forward fixed rate is a fixed loan rate on a specified balance that can be drawn on or before a predetermined future date. The table below lists the additional cost incurred today to fix a loan at a future date.

FORWARD FIXED RATES

Cost of Forward Funds

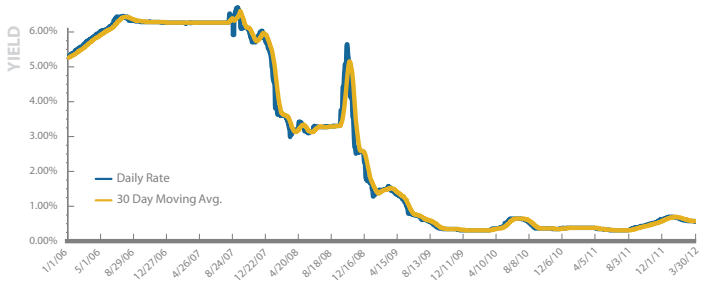
Forward Period (Days)	Average Life of Loan			
	2-yr	3-yr	5-yr	10-yr
30	5	6	6	6
90	5	13	13	13
180	5	21	23	23
365	19	44	47	45

Costs are stated in basis points per year.

SHORT-TERM INTEREST RATES

This graph depicts the recent history of the cost to fund floating rate loans. Three-month LIBOR is the most commonly used index for short-term financing.

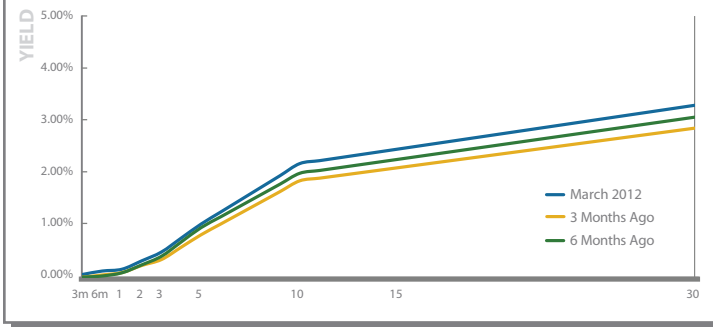
3-MONTH LIBOR



RELATION OF INTEREST RATE TO MATURITY

The yield curve is the relation between the cost of borrowing and the time to maturity of debt for a given borrower in a given currency. Typically, interest rates on long-term securities are higher than rates on short-term securities. Long-term securities generally require a risk premium for inflation uncertainty, for liquidity, and for potential default risk.

TREASURY YIELD CURVE



CoBank Contributes $2.5 Million for Commodities Research Center at the University of Colorado

CoBank recently announced a $2.5 million contribution to the University of Colorado in support of its new Center for Commodities. The three-year gift is designed to help establish CU as a global leader in research, education and training in the field of commodities, including agricultural and energy commodities that play an increasingly vital role in the world economy.

CoBank's gift was acknowledged in a ceremony this month as CU officially launched the J.P. Morgan Center for Commodities at its downtown Denver business school. J.P. Morgan Chase is another key sponsor, contributing $5.5 million. The ribbon-cutting event featured CoBank President and CEO Robert B. Engel, Blythe Masters, head of J.P. Morgan Global Commodities, U.S. Sen. Michael Bennet of Colorado, and CU President Bruce Benson.

The Center for Commodities will be housed in the new $45 million CU Denver Business School building where students will learn the basics of commodities trading at a "desk" on the main floor of the building.

"CoBank is delighted to be part of this exciting, visionary program at CU Denver," Engel said. "As a provider of credit to agribusiness and energy cooperatives across the U.S., we have a strong interest in commodity markets and the impact they have on our customers and rural America."

The world of commodities has never been more dynamic or more important than it is today. Commodities are the building blocks of many of the products we consume and as global demand grows it will become increasingly critical for business and agricultural leaders in the U.S. to understand how commodity markets are going to evolve and change.

"We don't see this as simply a gift to the school," said J.P. Morgan's Blythe Masters. "It is an investment to better prepare our future and existing talent and improve public understanding through exciting new research."

Construction on the facility is expected to be completed in June. The building's commons area and one of its lecture halls will be named for CoBank in recognition of the gift. In addition, a portion of the bank's contribution will be used to endow a professorship. Other dollars have been earmarked to fund a scholarship program for students to attend the school from rural communities around the country.

"The rural scholarship fund is an important part of our broader gift, and it supports CoBank's overall mission to serve rural America," Engel said. "We hope the fund will create new opportunities for students from rural communities, particularly those who plan to pursue their careers in the agribusiness or rural energy sectors after earning their degree."

About CoBank

CoBank is a cooperative bank serving vital industries across rural America. The bank provides loans, leases, export financing and other financial services to agribusinesses and rural power, water and communications providers in all 50 states.

CoBank is a member of the Farm Credit System, a nationwide network of banks and retail lending associations chartered to support the borrowing needs of U.S. agriculture and the nation's rural economy. In addition to serving its direct retail borrowers, the bank also provides wholesale loans and other financial services to affiliated Farm Credit associations serving more than 70,000 farmers, ranchers and other rural borrowers in 23 states around the country.

Headquartered outside Denver, Colorado, CoBank serves customers from regional banking centers across the U.S. and also maintains an international representative office in Singapore. For more information about CoBank, visit the bank's web site at www.cobank.com.