Good afternoon everyone and welcome to our webinar, Agricultural Research Policy in High-Income countries. My name is Nancy McNiff and I will be your host. This webinar is being recorded and will be posted on the ERS website. At any time during this webinar, you may enter a question into the chat feature at the bottom left corner of your screen and our speaker will answer at the end of the presentation. Our speaker today is Paul Heisey. Paul is an economist in the Structure, Technology and Productivity Branch at the Economic Research Service, USDA. Paul received his PhD in agricultural economics from the University of Wisconsin-Madison. His work focuses on agricultural science policy and, in particular, public and private sector agricultural research and development, intellectual property, and genetic resources. I think we're ready to start now Paul, so you can begin your presentation.

Thank you Nancy, thank you all for joining us this afternoon. This presentation is based on our report, you can see that title to the right. We also have an associated article in our ERS magazine Amber Waves. Information on how to obtain the report or the Amber Waves article will also be available. I'd also like to thank my co-author Keith Fuglie who made many and quite varied contributions to this report.

Three main points that I'm going to stress this afternoon are listed here, and I'm going to return to these at the end of the presentation so we can go over them again. The first is that productivity, which depends on research and innovation, is what drives agricultural growth. Agricultural productivity growth can help to keep food prices low, free resources for use elsewhere in the economy, and protect the environment. Second point is that public agricultural research investment in high-income countries has stagnated, while private R&D investment and public investment in developing countries have both continued to grow. A closer look at some of these funding trends aid in understanding current pressures on public agricultural research budgets. Thirdly, public agricultural research systems have responded both to the funding trends that we're talking about, but also to other factors such as the increasing role of the private sector changing societal expectations of research in several different ways: diversifying funding sources, coordinating more closely with the private sector, and broadening their research agenda. We'll talk more about some of these changes the extent to which they have met their objectives and what they have meant in terms of funding trends. And, again I'll come back to these points at the end of the presentation.

Globally, growth in agricultural output has come increasingly from growth in productivity, not growth in inputs. And, we can see this both for the world as a whole, on the left, high-income countries on the right. The blue line on the top is the growth at an average annual growth rate in agricultural output. And, you can see that from the leftmost time period, which is the 60s 70s 80s, 90s and then 15 years from 2001 to 2014, you can see that global agricultural output has grown on average between 2 and 3 percent every year, that's the blue line. However, the pink colored column below shows the growth rate in agricultural inputs. Agricultural inputs have grown very rapidly in the first decade, but slower and slower each year. So, agricultural inputs are growing slower than agricultural outputs. And, by the last two decades in the world that difference has accounted for almost 75 percent of the globe in output. And, we call that difference the total factor productivity in agricultural production. In high-income countries, the patterns have been some ways similar in some ways a little different. The blue line once again on the right hand side represents growth in agricultural output, and it's tended to fall over the period.

But, you can see that input use has decreased and in fact in the last three periods listed there the column is negative so input use is decreasing since nineteen the early 1980s in this graph which puts things together more or less by ten year periods. So, again the difference is growth in productivity. So, you can see that growth in productivity is actually higher than growth in output in the last three periods. This means that agricultural output has continued to grow, fewer inputs are being used, and this has freed up resources such as land and labor for use elsewhere in the economy.

These same data are presented again for the entire period from 1961 to 2014 with the upper red line representing the growth in agricultural output in the aggregate in high-income countries from 1961 through 2014. The index number is set at a hundred in 1961. This means that by 2014, agricultural output in these countries has nearly doubled. Just as the previous slide would have suggested agricultural inputs also increased at a lesser rate up to the late 70s and then began to fall, by 2014 they were 14% lower than they had been in 1961. This is the aggregate. The patterns of change in agricultural output and agricultural input indexes varies somewhat for different groups of countries and those can be seen in our report.

Investment in research has been a major factor leading to agricultural productivity growth. Governments have invested in agricultural research in many ways because knowledge is what as economists we call a public good. For our purposes here, this means that private inventors are often prevented from capturing a sufficient return on investment in knowledge creation. For example, technological innovation such as new seeds are often difficult and expensive to develop, but then comparatively cheap to distribute and copy. Another reason for the historical role of government is that farms are generally too small to conduct their own research. Even the largest farms in the United States today are in many ways characteristic of what you would call a small business for the entire economy. So, even a large Midwestern cash grain farm does not really have the resources to develop its own corn hybrids or soybean varieties. Similarly, a large dairy operation in California doesn't have the resources and the time to develop robotic milkers or whatever technology would improve their productivity. There are, however, a lot of investments by the private sector in agricultural R&D. And although some of the benefits from this research do accrue to the inventor, new knowledge often spills over beyond the local or specific applications intended by the inventor. And this is another reason why the private sector investment might not meet all the social objectives we would want to have from research. Governments also provide exclusion mechanisms such as patents to encourage private investment in agricultural research. At this point, and we'll talk a little bit about this later, there are also other sources of knowledge that might become applicable to agricultural production in a given country. These would include research in other countries, research in related scientific areas, such as basic biology, biomedical science, or computer science.

Public agricultural R&D has had a major impact on agricultural total factor productivity growth. We evaluated 14 statistical studies that covered nine high-income countries in total. Some countries had multiple studies. One study covered 11 countries of the European Union. The estimated social rates of return to public R&D ranged from 4% to 83% with a median of 29 percent. Now, these statistical studies are usually done trying to account from other factors that might increase agricultural productivity. One would be research from the private sector, another would be research from other countries, another would be research in other scientific fields.

Sometimes these are modelled explicitly, sometimes they're included as a time trend. Most studies also attempt to account for the influence of other sources of innovation. These could include agricultural extension, farmer education, infrastructure development, farm structural adjustment, and so on.

Turning to trends in public agricultural R&D in high-income countries, this has been a shrinking share of global agricultural R&D. The upper right pie is public R&D by high-income countries in 1990 and then in 2011. And we've adjusted these to account for inflation. And, we can see that it has grown about 25 percent from over 14 billion in 1990 to 18 billion in 2011. But this is only a 25% rate of growth. Public R&D by other countries has more than doubled from about 11 billion to 24 billion, that's the lower right pie. The lower left pie is R&D by agricultural input companies, and that has nearly doubled from 7.6 billion to 14.3 billion. Finally R&D by food manufacturing companies is in the upper left pie, that is less likely to have direct impacts on agricultural productivity, but it's often included in research total so we do that here, and that has also more than doubled.

Here is a look at the trends over a long period of time from 1960 to 2013. This shows the growth of public agriculture R&D in high-income countries from way back in 1960. It grew quite rapidly over the first years of that period. We can debate on when the exact period of slowing began, but definitely it was faster between 1960 and 1990 than between 1990 and 2009. And, then you can see since the global recession of 2008-2009, it has actually declined in inflation-adjusted terms. The countries that were responsible for the majority of the decline are the United States and some of the southern European countries, but in general the global recession has had noticeable impact on public agriculture research spending. In 1960, the United States accounted for over a third of this high-income country total. Now, it is slightly less than 25 percent.

Public agricultural research intensity is higher than the research intensity for all public research. What do we mean by this? This is a measure that is often used to compare research spending for a given sector or for the entire economy with the size of this economy. So, the blue column for each country compares public agricultural research investments to agricultural GDP expressed as a percentage. The red oval in the center is the average for all countries. This is over the period 2009 through 2013, and you can see that it's about 3%. The red or orange column compares all public research, not just for agriculture, any public investment in scientific research to the entire size of the economy. And you can see for individual countries and for the countries in the aggregate, that's the countries represented with the red oval, that this is roughly 1% or less. So, this means that the public research intensity for agriculture is greater than public research intensity for the entire economy. Another way of saying the same thing would be to say that agriculture's share of public research and development is larger than agriculture's share of the economy. There are several reasons for this. One is that historically, public R&D for agriculture has compensated for relatively low private R&D in this sector, even given the recent large increase in private R&D for agricultural inputs. Second, agriculture is a technology dependent sector. By technology dependent, we mean one (as shown in one of the previous slides) one for which growth and productivity has been more significant than growth in inputs in creating output growth. Technology dependent sectors tend to have larger research intensities. Finally, countries have also been increasingly spending R&D funds to address a range of public goods in addition to food production or food security. These relationships imply that as countries get richer, agriculture tends to decline as a share of total GDP. It's now less than 2% in aggregate across all high-income countries. So, agriculture's share of public research also declines. At the beginning of the early 80s, agriculture had about 9% in the aggregate of all public research in high-income countries; today it's just over 5%.

We can also look at research intensities over time. These are essentially measuring the same things as in the previous slide, but here we're taking a view from 1960 up to 2013 for different groups of countries. The research intensity, as we remember, is the public sector investment in research divided by AG GDP. So, if this research intensity is growing, this means that AG R&D is growing faster than AG GDP. Some models of AG research suggest that this is necessary for long-term increases in agricultural productivity. The black dotted line is the aggregate across all countries, but we can see differences across time and for different groups of countries. In the agricultural exporting countries of Oceania – that's Australia, New Zealand, North America, Canada, and the United States. This ratio has tended to stop growing or even drift slightly downward. The red is Australia, Canada, and New Zealand taken together. That reached a peak in the early 80s and has drifted downward. In the United States (that is the blue line), that research intensity rose to the early 2000s and has fallen since. The Purple Line is Northwest Europe. The Green Line is Asia, that's Japan and Korea. And, you can see that now their intensities are higher than in some of the other country groupings, but they too in aggregate have had falling research intensities since 2009. We see some countries have had much lower research intensities down below. The yellow line represents southern European Mediterranean countries and the grey line countries in Central Europe. These are former centrally planned economies. So, you can see that there are changes in agricultural intensity, but regardless of what country grouping a particular country falls in, this intensity has tended to fall since the recession.

Now let's turn to some other related drivers of change in public agricultural research systems in high-income countries. We've looked at part of the reason for the squeeze in funding in terms of trends, in terms of the shrinking role of agriculture within the total economy. Here are some other factors that have played a role in changing public agricultural research systems. After World War II, a number of countries experienced food shortages, which provided some incentives to invest in research. By the 1980s, agricultural surpluses were pretty common and so some people asked, well we're already growing more than enough food, why do we need to do research on growing more? Second, society's expectations of what research could do have changed. Environmental, food safety, animal welfare, and other social objectives became increasingly important components of agricultural research policy. Private sector research took on an expanding role in the agricultural research portfolios of many high-income countries. And, in individual countries there were often specific ideas again related to some of these things motivating policy reform. In the United States for example, for a long time there have been those who argue agricultural research funding should be more like research funding in other scientific areas, focused more on competitive grants rather than block grants or formula funds. This one below might apply to a number of countries, but it's particularly applicable to Australia, where the arguments for a long time were farmers should contribute more and more directly to agricultural research funding, since they may directly benefit. Our description of things that have been going on are based mainly on four countries. We wish we would have more information across a group of countries. The Organization for Economic Cooperation and Development or OECD is doing a series of studies for all their member countries of agricultural innovation systems, and as these studies are completed and published, this kind of analysis may be expanded to include more countries.

Some measures have been aimed at increasing farmer support, both of public and private research. One of these measures is producer levies, and these are levies that are made on commodity R&D in this country. They're often voted on by a particular group of farmers who might benefit. What we're going to do here is compare them in Australia and the U.S., but I will mention in two other countries that we looked at, Netherlands and the United Kingdom, both of these countries also tried producer levies. Producer levies in the UK have basically been whittled down to the only thing that they're supporting now is Agricultural Extension. Producer levies in the Netherlands have been abolished completely as of 2014. In Australia, we look at the levels of funding for research in commodities that can be related to producer levies, and we can see that the producer levies (that's the dark blue part of the column at the bottom) is matched by a government contribution (that's the light blue), and then there are a few other sources of funds that go to the research and scientific development corporations in Australia. So, you see that that total comes to over 1.2 percent. On the other hand, in the United States, the blue column again is what is actually going into R&D; and you can see that's very low. The white area there consists of funds that come from producer levies, but they're directed not to R&D, but to market promotion. The reason that we believe that these have been relatively successful in raising funds for research in Australia is because of the government match. Royalties on feed can also be used to generate funds for plant breeding. This has been used quite extensively in Europe. They have a mixed record of success. We refer to a source that allows you to look up what might have happened in different countries. In the U.K., for example, royalty levels do not seem to have been set at a high enough amount to really support private research when the public got out of wheat breeding in the U.K. Royalties might be paid at the time seed is purchased or when a farmer takes his or her own harvest to someone who will condition it, so it will be in better condition to be planted as seed. The point at which royalty rates are set might determine if sufficient funds are then available to support plant breeding. In Australia, a different point of collection, end point rail royalties collected at the time of grain sale, so when a farmer sells the grain harvested then the variety is assessed a royalty is assessed and that is returned to the plant breeder, and end point royalties might be easier to administer across all farmers. These end point royalties in Australia have facilitated something of a switch from public to private plant breeding in that country and have generally provided incentives for plant breeding research.

In some countries, stronger intellectual property rights have contributed to increased private plant breeding. A strong system of plant breeders' rights has encouraged private plant breeding in the Netherlands. In the United States, utility patenting has intensified private R&D for biotechnology and plant breeding, but this R&D varies considerably by crop.

Competitive funding in a number of countries has been related to diversified funding sources, both because research institutions are going to more sources than they have before, and because competitive funders have different objectives for funding research. And, so therefore they might put out grants that will direct research into some broad areas that they are particularly interested in. We can see that in the Netherlands here we're comparing 1995 to 2013 in agricultural research. The medium blue large column on the left is the funds for Netherlands research that come from government structural funding, just kind of like block grants or general structural funding, and you can see that shrunk from perhaps 75-80 percent to more like 40 percent in 2013. We talked about commodity levies, that's the gold you can see that that's pretty much shrunk. Other sources in there are government contracts or competitive funding, that's in orange, from the EU, that's in gray, from the companies and then finally fees and product sales account for the green at the top. We also have some evidence that competitive funding in the UK and the Netherlands moved research into more basic science and into higher quality research. Evidence on the influence of competitive funding on agricultural research on the United States is mixed. Different studies have reported different results on whether U.S. competitive funding is associated with more fundamental research. Different studies also differ in their assessment of whether competitive funding in the U.S. has increased the impact of research.

Just to reiterate the three main points: productivity, which in turn depends on research and innovation, drives agricultural growth; public agricultural research investment in high-income countries has stagnated, while private R&D investment and public investment in developing countries have continued to grow; in response to funding trends, in response to growing private sector research, in response to changing societal expectations, public research systems have responded by diversifying funding sources, coordinating more closely with the private sector and broadening their research agenda.

Here are some implications. Agricultural research policy reforms have had a mixed record. What do I mean by that? We can talk about them in terms of whether they met their stated objectives. We can ask, have they made research more efficient? Have they enhanced the productivity gains from agricultural research? So, in some cases the answers are yes, in other cases the answers are maybe, and we need to look at them more closely. However, one thing is pretty evident, that they have not significantly increased funding for public research. They've diversified the funding sources, but they have not increased the amounts in real terms. Even if food demand growth slows, agriculture will need new innovations to maintain present levels of productivity. The last three points summarize some of the reasons why other sources of research investment are unlikely to substitute completely for public research in high-income countries. Private research has replaced some public research, but private firms under-invest in fundamental sciences, pre-commercial science and technology platforms, and even some applied research that may yield insufficient financial returns. Agricultural research tends to be location specific, so developing country research often in tropical environments can't substitute for public research in high-income countries. And in general, public research in high-income countries continue to take the lead in fundamental advances in agricultural sciences that make major technological innovations possible. We took a look at a few indicators, for example, the top-rated universities in agricultural sciences and in biological sciences, in scientific publication in citations, and in production of PhDs in agricultural sciences, and in all these the institutions in high-income countries have been playing a very important role for a long time and continue to do that today.

So, I thank you very much. Here's some information about the report and the Amber Waves article. And Nancy let's go over to you.

Thank you so much, Paul. Again, if you guys have any questions for Paul, you can enter your question into the chat feature at the bottom left-hand corner of your screen.

But first, I have a question for you, Paul. Haven't most of the recent increases in agricultural productivity in the United States come from genetically modified crops developed by the private sector? And, if so, what does this imply for the future of public agricultural research?

Okay, this is an interesting question and an important question, and I would argue that genetically modified crops have been a very important part of agricultural production in the U.S. since the late 1990s. However, there are several things we can say. First off, genetically modified crops are particularly relevant for basically six commodities – three where they've had a long term impact that would be corn, soybeans, and cotton – and so there are a lot of other crops such as wheat where yield increases have continued even though they might not be as great. There are other things that you can say even about those crops that have had genetic modification. Some economists have tried to look at yield increases, and yield only measures the output per one input, that's land. So, it's not the same as total factor productivity. But, looking at yield increases in corn, the estimates that I've seen suggests that over recent decades maybe half of those have come from the genetic modification and half of them have come from continued improvement in other aspects of corn. There are other things that have to do with crop production, that's upstream research. For example, the public sector is working on incorporating drought tolerance into soybeans, and things like that. Then there are a lot of areas where the public sector does research, for example the environmental implications of agricultural production, food and nutrition implications of agricultural production, where the private sector really at present does not do a lot of research.

Okay, we have another question. Where are the dollars going mostly in research? Is it genetics or yields?

Well, genetics are really a major factor in contributing to yields. So, they contribute to yields in two ways. One would be to raise yield potential, the other would be to increase the resistance or tolerance to pests, diseases, or environmental conditions. So, it depends on, you really have to dig down into the weeds, and if we could focus on different crops, I have some data. I don't have it immediate at my hand. We used to argue that for just crop research, about half was going into crop improvement. And by that we mean genetics and yield improvement, which go together and about half into other things like management. But, that's kind of a rule of thumb. And, you have to look at it over time, and you have to look at it for individual crops.

Okay, how could the increased research funds impact farmers?

Well, one would hope that the benefits of research do come down to farmers. And, this is an interesting question, because people have looked at this in various countries, particularly the United States, trying to determine how much of the benefits from research go to the farmers. How much go to consumers in the form of lower prices, higher quality products, and how much go to the research developers, private companies, if they're the ones who have developed the particular technology. So, I think we can answer that for some of the…we've been talking about some of the genetically engineered material that has been developed by the private sector, and this definitely has been taken up very rapidly by farmers. One of my colleagues is looking at some more recent innovations in tolerance to stress. And, that's not to pests and diseases, but to drought in corn. And, in that case, it's very interesting, because one of the companies out there has a genetically engineered drought-tolerant corn, the others have not genetically engineered, but drought-tolerant corn that they developed through different breeding techniques. So there are a lot of ways that this can impact farmers in the forms of new technology.

Okay, we have a question, hybrids are mostly funded by private sector funds, while in wheat and barley where spillage is high, research depends on public funding. What does the future look like for these specific crops where the risk of spillage is high?

Okay. That's a very interesting question, and we've been following that for a long time. There's been interest in developing wheat hybrids, oh, at least since I think the 70s. I don't know if I can trace it back even farther than that, but it's never really taken off in terms of hybrid wheat production, partly because of the biological nature of the crop. The private sector has been interested in wheat breeding, then gotten out, then gotten back in again. Right now, there is increased private interest in wheat breeding. A lot depends on the institutional nature. In this country, the way things are set up right now, the capture of benefits from an improved wheat variety are perhaps still harder to get. In the Australian case, where we talked about the endpoint royalties, that has proved to be a fairly effective mechanism in providing resources that would go back to a private wheat breeder. And so, you can go country by country and look at different things, but at each stage for each crop there is going to be a different public/private balance. And in some sense in this country, what we've seen is that as the private sector breeds more for a given crop, the public sector will do less and less of that and move upstream in terms of their research.

Okay. We have a question about China. Is China considered in any of the data for this report? And, was China R&D included in the regional generalization of Asia? And, is China now spending more on agricultural research than the United States?

The answer is yes. The answer to the first question is not directly. This report focused on high-income countries. In other work, we've actually looked at research spending by China. So, the answer to the second question, yes China is now spending more on agricultural research than the U.S. The China totals are not included in our high-income Asia. Our high-income Asia refers solely to Japan and South Korea.

Okay. What percentage of this research funding goes to plants versus animal work?

This is a good question. I can answer more directly for the United States than for the other countries. In the United States, if I recall correctly, of the public sector totals, and I may not have my figures exactly right here, but it's probably currently about 1.3-1.4 billion to plant research, under 1 billion to animal research. Again, in animal research, the division of labor between public and private tends to be different. The private sector will do a lot of the research in animal pharmaceuticals. Other aspects of animal health, like vaccines, tend to still come out of public sector research. The private sector is involved in animal breeding, but a lot of the basic data and underlying work on animal genetics is still in the public sector. But, in general, the crops research amount in this country is higher than the livestock research. Probably if we dug down country-by-country, we could get some information for some countries. I probably could get it for Australia if I look deeply enough. For other countries, I'm not sure what the answer is.

Okay. Your report shows that a lot of high-income countries are moving from formula-funded research to competitively-funded research. How has this affected the quality and kind of research done by public institutions?

Well, we've showed so far that we have information for a few countries. It would be nice to get information for more countries, but definitely in the Netherlands and the U.K., the quality of research has been high as a result of competitive funding, and the kind of research has become more diversified to address a whole bunch of different topics. The interesting thing there is when you take it one step further to what is the actual impact on agriculture, we can see that agricultural productivity in the Netherlands has continued to grow quite nicely. Whereas, the U.K. agricultural productivity has kind of lagged behind a lot of other European countries. So, there are a lot of complex factors that are even translating there between what is high-quality research and what's actually happening in terms of productivity. The United States has not had as much of an experience…has had a long-term interest in competitive funding since the 1970s. There's a competitive funding program within USDA that is growing. But another thing that's happened in the U.S. is that over the past thirty years or so, agricultural scientists in say land-grant institutions are increasingly getting funding from other federal agencies such as National Institute for Health, National Science Foundation. And that's very often also funded competitively. When they get funding from these other sources, they're probably reflecting a more diverse set of objectives and therefore diversifying their research.

Okay. We have a question about organics. Do you have a breakdown of private versus public funding for organics?

We do not. I know that my colleagues here in the Economic Research Service who work on organics have a look at public figures for organics, for organic research, at least in terms of organic seed related research and other things like that. And, I don't want to give you the wrong impression. If you would contact me afterward, I could put you on to the exact number. But, if I recall correctly, some of that funding is in the range of 10 to 20 million. I may be off, but that's like about where it is. In terms of private funding, that so far appears to be quite small in terms of organics. There probably is some there, but it's probably less than the public funding.

Okay. Do you have a reason why the private sector investments in agricultural R&D have increased?

There have been several factors involved there. One would be increasing scientific opportunity in terms of the recombinant DNA technology that came out of biomedical research in this country that eventually went into the production of genetic engineering. Another is changes in incentives. For example, intellectual property rights, extension of patenting to products particularly in the plant breeding area, but in other areas as well. Another reason is increased global trade, increased markets. And then there's a kind of a long-term question, to what extent does private investment respond to agricultural prices? And some people would argue that the recent rise in agricultural prices, which now appears to have leveled off or be falling again, but that that may have also induced private sector investment. So very often, we say that the biggest factors appear to be increased incentives in terms of intellectual property, increased scientific opportunities, and technology platforms that the private sector can build on, and expanding markets.

Okay. This is sort of a follow-on question to that. The increases in private spending on agricultural research have offset the decline in public agricultural R&D. What kinds of research are likely to be neglected by the private sector that the public sector might have done?

Okay. All right, I just lost my screen there, so that's the reason for my hesitation. The public sector, for example, is more likely to create technology platforms, do upstream research, maintain genetic resource connections, look at what those might be found useful for, and look at things across a whole sort of area. Public agricultural research can also serve as a bridge between upstream sciences like biological sciences, computer sciences, data sciences and so forth, and the private sector. At the same time, there are certain kinds of applied areas like environmental research, research related to nutrition, where the private sector is likely to under-invest compared with what society might want from research. The private sector first and foremost is going to focus on research areas where they think that they will generate revenues and profits.

And, one last question. What is driving agricultural R&D funding in developing countries?

This is an interesting question, and more information on this can be obtained from our colleagues at the International Food Policy Research Institute. But, it's clear that in particularly large developing countries, China, Brazil, India, there's been a push to increase research funding. China in particular has an incredible rate of growth in agricultural research funding, and as I may have mentioned before, they have been pushing research funding across all sectors. And in fact, it's estimated than in just a few more years, China's total research portfolio, that is, across all sectors may be greater than the total research portfolio in this country, in the United States. So again, they probably are realizing that productivity growth is the key to prosperity, not only in their agricultural sectors, but also in their overall economy. At the moment for example, again looking at Brazil, Brazil is a big agricultural exporter, so they would like to invest in research to promote their exports. At the moment China is a big producer, but it's a very populous country, so in a lot of cases, they're still importing. Some of these countries have environmental issues which they're beginning to recognize and may want to develop research approaches to address those. The trends in smaller developing countries may be different, and some of the smaller developing countries, lower-income countries in places like Africa, may not have as rapid increase in agricultural research investments as some of the bigger ones that we've been talking about.

Okay, Paul, I think that's all the questions we have. Thank you for a very interesting presentation. And, thank you all for joining us for this, and have a wonderful day!

Thank you!