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Executive Summary

China has serious ambitions to become a global leader in artificial intelligence (AI). The Chinese government, at the central and local levels, has announced large amounts of planned expenditures to support AI activities; however, it is not clear how much of the *planned* expenditures by the Chinese government is *actually* being expended, who is providing the money (e.g., central government, local government, enterprises, private investors), to whom the money is going, or on what the money will be spent. The absence of information on these issues makes it challenging for Western analysts, media, and policy makers to understand the extent of China's activities in support of AI. This lack of information can lead to confusion and misleading comparisons between Chinese and U.S. expenditures on AI, which have caused alarm among some policy makers and observers.

The highest quality data on U.S. Federal expenditures on AI research and development (R&D) are provided by the Office of Management and Budget (OMB) and the Networking and Information Technology Research and Development (NITRD) program. Comparisons between U.S. Federal and Chinese expenditures in AI should use comparably produced data. In other words, the data should be annualized, focused on R&D, focused on AI, be provided by the central government, and be based on outlays or government budgets. Our hypothesis is that information in Chinese government documents and reported in the Chinese media is too poorly defined—in terms of timing, sources, and purpose—to support credible comparisons between U.S. Federal and Chinese central government expenditures on non-defense AI R&D.

This document describes the tentative framework for testing our hypothesis. It identifies 10 critical aspects of the expenditures associated with Chinese AI activities. The critical aspects are information that we believe is necessary to support an assessment of the expenditure's comparability to U.S. Federal Government expenditures on AI R&D. By examining the critical aspects, we will be able to assess whether each activity represents an expenditure that is an outlay of money, substantially supports R&D, substantially focuses on AI, and is funded by China's central government. If all four of those criteria are true, the activity's expenditure can be judged as comparable to actual U.S. Federal Government expenditures for AI R&D. The proportion of Chinese expenditures that are deemed comparable with U.S. Federal expenditures will either support or undermine our working hypothesis.

The application of our framework to publicly announced Chinese AI activities, which will be the subject of a subsequent report, will provide the assessment of the comparability

of each activity's expenditures with U.S. Federal expenditures on AI R&D. The framework described here is tentative and may evolve as the analysis progresses. The goal of this document and the future analysis is to test our hypothesis—not to estimate China's total expenditures on non-defense R&D for AI. In line with this goal, we do not plan to investigate all possible sources of expenditure data on non-defense R&D for AI; instead, we limit our scope to activities whose awards are publicly competed, because they are the most likely to have generated publicly available data. We believe that these publicly competed activities will provide a sufficient amount of data to test our hypothesis and provide valuable insight into Chinese expenditures on non-defense AI activities.

Contents

1. Introduction

A. Background

China has serious ambitions to become a global leader in artificial intelligence (AI). The Chinese government, at the central and local levels, has announced large amounts of planned expenditures to support AI activities. It is challenging for Western analysts, media, and policy makers to understand the extent of these Chinese activities in support of artificial intelligence. This can lead to confusion and uneven comparisons between Chinese and U.S. expenditures on AI, which in some cases have caused alarm among some policy makers and observers.

For instance, the Tianjin Municipal Government has announced a $15 billion fund to support the development of the AI industry (Beijing Monitoring Desk 2018; Tianjin 2018). This announced expenditure has been compared unfavorably with U.S. Federal Government expenditures in AI research and development (R&D) (Savage and Scola 2019). Such a comparison is likely to be misleading because, unlike the U.S. Federal Government expenditures with which it was compared, the announced expenditure from the Tianjin government does not appear to be annualized, focused on R&D, from the central government, or an outlay of money. In general, it is not clear how much of the *planned* expenditures by the Chinese government is *actually* being expended, from where the money is coming (e.g., central government, local government, state-owned enterprises, or individuals), to whom the money is going, and on what the money will be spent.

B. Purpose

Our hypothesis is that information in Chinese government documents and reported in the Chinese media is too poorly defined—in terms of timing, sources, and purpose—to support credible comparisons between U.S. Federal and Chinese central government expenditures on non-defense AI R&D. This document describes our tentative framework for testing that hypothesis, though the framework may evolve as we learn more. The application of our framework to publicly announced Chinese AI activities, which will be the subject of a subsequent report, will provide an assessment of the comparability of each activity's expenditures with U.S. Federal expenditures on AI R&D. The proportion of Chinese expenditures that are deemed comparable with U.S. Federal expenditures will either support or undermine our working hypothesis. The goal of this document and the overall analysis is to test our hypothesis—not to estimate China's total expenditures on non-defense R&D for AI.

2. Concepts of the Framework

To be policy relevant, the expenditures for Chinese activities must be able to be contextualized with expenditures for U.S. activities. To analyze an announced Chinese expenditure, concerns to address include: whether the intended use of the money is to support R&D; what fraction of the money will be used to support AI; the sets of economic actors that may be the source or recipient of the expenditure; the funding mechanisms by which money flows from the source to its recipient; and the credibility of the expenditure, both in terms of the source of information and the degree to which the money has reached its final recipient. This chapter introduces the key ideas necessary to address the above concerns for an assessment of Chinese expenditures for AI. Chapter 3 will use these concepts to demonstrate how the assessment can be performed.

The first two key ideas are the classification of expenditures as R&D and as AI. We propose to use U.S. Federal definitions of R&D, as they are the basis for the highest quality U.S. estimates of AI R&D expenditures. We note the challenges with using a consistent definition of AI and do not provide one here; instead, we draw attention to the fact that activities claiming to support AI may be supporting many other topic areas as well.

Next, we define four sets of economic actors in China, and their corresponding sectors in the United States, as potential sources of the expenditures. The four Chinese sets are Central Government, Local Government, Enterprise, and Individual. We define the Chinese central government as being approximately analogous to the U.S. Federal Government for the purposes of our expenditure comparisons. Expenditures for some activities may contain money from the central government mixed together with money from other economic actors in unknown proportions; it is difficult to determine the fraction of an announced expenditure that is attributable to the Chinese central government in these cases. An understanding of the funding mechanisms used to support innovation in China can provide partial clarity on this fraction. Thus, we outline the five major funding mechanisms that we will investigate, noting that there are other funding mechanisms for R&D in China that we will not address in the proposed study.

Finally, we also discuss the credibility of Chinese announcements for AI R&D. While the authoritativeness of the source is important, we will focus our assessment of credibility mainly on the degree to which the announced expenditure has been spent.

A. Expenditures on R&D versus Other

Several definitions exist for R&D. They vary in terms of their inclusivity. The definition of R&D used to classify expenditures should be comparable with the highest quality data available on U.S. Federal Government expenditures on R&D. The organizations responsible for tracking expenditures on R&D made by the U.S. Federal Government and U.S. businesses are the Office of Management and Budget (OMB) and the National Science Foundation (NSF). Therefore, our analysis of Chinese R&D activities will use the definitions of R&D expenditures employed by OMB and NSF. We assign an expenditure that does not meet those definitions of R&D to the category of "other" expenditure.

OMB Circular A-11 states that "research and experimental development activities are defined as creative and systematic work undertaken in order to increase the stock of knowledge—including knowledge of people, culture, and society—and to devise new applications using available knowledge." The construction of Federal R&D facilities may also be included if they

> are necessary for the execution of an R&D program. This may include land, major fixed equipment, and supporting infrastructure such as a sewer line, or housing at a remote location. Many laboratory buildings will include a mixture of R&D facilities and office space. The fraction of the building directly related to the conduct R&D may be calculated based on the percentage of the square footage. (OMB Circular A-11)

Construction of other facilities, such as office space, is to be excluded.

For businesses, NSF's National Center for Science and Engineering Statistics (NCSES) defines R&D activities similarly, with the following *exclusions*:

- "Adaptation of an existing capability to a particular requirement or customer's need as part of a continuing commercial activity"; and
- "Activity, including design and construction engineering, related to the construction, relocation, rearrangement, or start-up of facilities or equipment other than the following:
  - Pilot plants [that are not of a scale economically feasible to the entity for commercial production]; and
  - Facilities or equipment whose sole use is for a particular R&D project." (NCSES 2018)

B. Expenditures on AI versus Other Topics

Expenditures can be classified as "AI" versus "other" at two levels of fidelity. The coarser fidelity approach is to classify expenditures as AI if they self-identify as AI, based

on all available information about the expenditure. This is the approach that we propose to use in our analysis. The higher fidelity approach is to evaluate each expenditure based on a prescribed definition of AI. Definitions of AI are varied and, unlike the definitions for R&D, we are unaware of a U.S. Government definition of AI that is sufficiently specific to allow for the higher fidelity analysis. The only official definition of AI of which we are aware appears in the National Defense Authorization Act for fiscal year 2019. This definition is abstract and would be challenging to apply in a consistent manner to the data we have gathered. As such, we will not posit a definition of AI; instead, our analysis will list thematic information about each self-identified AI investment to enable other analysts to apply their own definition of AI.

Announced Chinese activities may contain AI in their name or may heavily feature AI in English language reporting about the activity; however, the proportion of expenditures toward AI within such activities should be investigated. We will focus our classification of the activity as "AI" versus "other" on determining whether the activity is predominantly supporting AI—self-identified and loosely defined—or is engaged in multiple topic areas. An announced AI activity may be classified as "other" if government documents or officials indicate that its expenditures will support other topic areas in addition to AI (e.g., robotics, integrated circuits, big data, cloud computing, advanced manufacturing). The fraction of an activity's expenditures that support AI versus other topic areas may require substantial effort to estimate. If an estimate cannot be produced, such an activity and its expenditures may be classified as "other."

C. Sets of Economic Actors in China and the United States

Money for China's AI activities comes from a variety of sources. To make comparisons with the United States, an appropriate grouping of the sources of money should roughly mirror the sources of money in the U.S. economy. STPI proposes to view Chinese expenditures on AI as originating from the following four sets of actors: central government, local government, enterprises, and individuals. The corresponding sets of U.S. actors are Federal Government, non-Federal Government, businesses, and individuals. In the context of China, if the word "government" is not qualified by "central" or "local," it should be understood to mean both central and local Chinese governments. Using these four actors, properly caveated comparisons between Chinese and U.S. activities can be credibly made.

China's central government has several branches that are partially analogous to the three U.S. Federal Government branches. The National People's Congress and its Standing Committee roughly map to the U.S. legislative branch. The Supreme People's Court and the Supreme People's Procuratorate roughly map to the U.S. judicial branch. The State Council and the Central Military Commission roughly map to the U.S. executive branch. A few features of China's central government do not clearly map to the U.S. Government,

such as the President of the People's Republic of China[1] and the National Supervisory Commission. Statements (e.g., policies) made by these bodies or their subordinates are authoritative and indicate central government involvement in any activities they have initiated. Expenditures made by the central government flow through the State Council and the Central Military Commission, similar to how most expenditures made by the U.S. Government flow through the executive branch.

We designate local governments as any government body that is not the central government. Provincial and municipal governments are considered local. They are grouped together because it is difficult and often impossible to separate their expenditures on R&D from each other. Some municipal governments are so large that they are effectively provincial governments as well, such as those of Beijing and Tianjin. The analogous sector for the United States would be all government bodies that are not the U.S. Federal Government.

Private enterprises in China are similar in many ways to businesses in the United States, but state-owned enterprises in China exhibit substantial differences. A Chinese enterprise in which government ownership is substantial is called a state-owned enterprise (SOE). Although SOEs tend to seek profits, the government involvement creates incentives for support of government policy objectives to override the pursuit of profits. However, in China, even private enterprises are subject to substantial influence from the Chinese government, a level of influence that is greater than the influence of Western governments on businesses in their countries. Because government money and influence are intimately tied to the operations of many Chinese enterprises, we recognize that at times expenditures by an SOE might be considered in some part a government expenditure; however, it is impossible to determine what fraction of that money should be counted as a government expenditure. For an analysis of Chinese expenditures, based on currently available data and with the caveats listed above, we believe that it is better to not try to incorporate expenditures by SOEs on AI R&D into Chinese government expenditures. An analysis that applies a non-zero percentage to enterprise AI R&D expenditures would require a thorough justification for the fraction chosen. For our analysis, we will map the set of Chinese enterprises, both private and state-owned, as being analogous to the set of U.S. businesses.

Contributions to R&D by individuals with high net worth are usually for activities about which these individuals are passionate. Their contributions are generally channeled to the ultimate recipients through grants from foundations or other such mechanisms. Though we have not found any Chinese activities that appear to be supported by

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[1] In contrast to the United States, the official role of China's President is ceremonial, similar to the Queen of England. Presidents, such as Xi Jinping, do wield enormous power; however, that power derives from other positions that they hold, especially the leader (i.e. "chairman") of the Communist Party of China. By convention, the Chairman is also designated as the President.

individuals, we include contributions by individuals into our framework for the sake of completeness. Examples of donations that support R&D in the United States include the Bill and Melinda Gates Foundation and the Howard Hughes Medical Institute.

D. Chinese Funding Mechanisms

Expenditures for activities may contain money from the central government mixed together with money from other economic actors in unknown proportions. Similarly, expenditures for announced AI activities may support non-AI or non-R&D activities in unknown proportions. If it is possible to infer from publicly available information the fraction of the announced expenditure that is provided by the central government in support of AI and in support of R&D, then the expenditure may not support our hypothesis. We can gain partial clarity on this fraction by understanding the funding mechanisms used to support innovation in China and connecting the announced AI activity to its funding mechanism.

In 2014, the State Council announced a reform and reorganization of China's innovation system (State Council of China 2015). The reform consolidated hundreds of overlapping, redundant, and underperforming science, technology, and innovation programs into five funding mechanisms (DSE 2018). While these five funding mechanisms will not cover all Chinese expenditures on non-defense AI R&D, awards made through these mechanisms are publicly competed; thus, it is likely that open-source data exists for use in our assessment. Due to the potential for data availability, we will investigate only activities whose expenditures are provided by these five funding mechanisms. The five funding mechanisms are:

- The National Natural Science Foundation of China, which is focused on basic and applied research;
- National Science and Technology Megaprojects, which are focused on producing breakthroughs in key technologies;
- National Key R&D Programs, which are focused on highly targeted R&D projects to improve the social and economic welfare of the people;
- Guiding Funds, which provide capital to start-ups and growth-oriented small-and-medium enterprises to stimulate innovation and technology transfers; and
- The Bases and Talents Program, which encourages the creation of research centers and partnerships, and attracts talented scientists and engineers to work in China.

Money from local governments, enterprises, or individuals may be incorporated into the funding streams of the central government's mechanisms listed above, excluding the National Natural Science Foundation of China. Also, expenditures made through some of

these mechanisms may not qualify as R&D. Provinces and municipalities tend to implement their own AI-related programs that mirror the central government's funding mechanisms, with no apparent central government involvement. These issues, which are particularly acute with guiding funds, complicate our ability to estimate the central government's contribution to AI R&D.

We have already noted that not all Chinese support for non-defense AI R&D will flow through the five mechanisms within our scope, nor is all of the money that flows through the mechanisms necessarily for R&D. Other sources of R&D financial support may come from stable funding provided to research institutions (e.g., institutes within the Chinese Academy of Science and public universities), tax incentives, subsidies, and other mechanisms of which we are currently unaware. We have also excluded all defense-related funding mechanisms. These exclusions are justified because our framework is not intended to produce a complete estimate of Chinese non-defense expenditures on AI R&D. While our framework could be adapted to apply to these other mechanisms in the future, we have excluded them from the current study because we believe that the five chosen mechanisms will provide sufficient coverage of Chinese activities for an initial test of the hypothesis.

E. Credibility of Reported Expenditures

Not all reported activities and associated expenditures are of equal credibility. There are two axes along which we assess credibility: source of the information and the timeframe of the expenditure. For instance, in terms of information sources, expenditures reported by the *Global Times* may not have the same credibility as expenditures reported by Xinhua—which, in turn, are not as credible as numbers reported by a ministry of the State Council, such as the Ministry of Science and Technology. Although information published by government ministries may be problematic, we believe that this information is the most credible information that is openly available and should serve as the starting point of any analysis. More accurate numbers may be produced by independent analysts, but such analysis would need to be transparent with methods and supporting data to be convincing.

The timeframe of a reported expenditure is also a factor in its credibility. Future expenditures are less credible than actual expenditures. We define actual expenditures as those where the money has been spent or where the budgeted money has been appropriated (i.e., set aside) and is thus likely to be spent. Future expenditures may be either planned or aspirational. Planned expenditures are those where the money has not yet been appropriated, but a plan with yearly budgets has been established. Aspirational expenditures are those where a desired amount of money has been specified, but there is no planned annual budget or where funding of the activity relies on circumstances substantially beyond the government's control.

3. Steps of the Framework

STPI has gathered a corpus of reported Chinese expenditures for AI activities, which are predominantly attributable to government documents or government officials. We will use the following steps to assess the comparability of each activity's expenditure to U.S. Federal Government expenditures for AI R&D: examine critical aspects of the expenditures, use those aspects to assess comparability based on four criteria, and then contextualize the assessment.

A. Examine Critical Aspects of Expenditures

The critical aspects of each announced activity and its associated funding mechanism are examined. Critical aspects are information necessary to make the assessment described in the following section. For many aspects listed below, the subjunctive "would" and "should" are used to indicate the way the funding mechanism is described in policy documents. This is to highlight that the implementation of the mechanism may not fully align with the official descriptions of how it "should" work. We believe that the critical aspects are the answers to the following questions:

1. What entities would provide the money and through what mechanism?
2. If more than one entity contributes to the mechanism, e.g., through matching funds, what proportion should each entity contribute?
3. Who would be the recipients of the money?
4. Under what conditions would they receive the money?
5. Is it an actual or future expenditure?
6. What is the timeframe of the expenditure and can it be annualized?
7. Are the recipients of the money substantially engaged in R&D?
8. Are the recipients of the money substantially focused on AI?
9. How does money flow from the source to the final recipient? Are there intermediate entities that may alter the answers to any of the above questions?
10. Is there evidence to suggest that the previously mentioned ways the mechanism should work are not the ways it actually works?

Questions 1 and 2 are to determine the extent to which the funds come from the central government, a local government, or a non-governmental entity. Each of these has

ramifications for the credibility of the funding numbers and the ability to apportion the correct amount of money to government and non-government sources. The answers to questions 3 and 4 have implications for whether the expenditures represent basic research, applied R&D, or predominantly non-R&D activities. Question 5 is designed to clearly identify the credibility of the announced funding, while question 6 forces all expenditures to be compared over equivalent timeframes. Questions 7 and 8 support the assessment that a funded activity is truly representative of AI R&D and may be substantially informed by the answers to the previous questions. Finally, questions 9 and 10 serve to examine whether the idealized understanding of the funding mechanism may not be reflective of its actual implementation.

These questions may still evolve as the study proceeds. The subsequent report that applies this framework to our corpus of data will detail the final wording of the above questions. It will also make explicit how the answers to the questions will be operationally used to assess the four criteria described below.

B. Assess Four Criteria

Once the questions have been answered for each reported activity to the extent that publicly available information allows, the activities can be assessed on the four criteria necessary for a fair comparison with U.S. Federal Government expenditures. Specifically, the assessment will estimate the extent to which the reported activities represent: a central government expenditure; an AI-focused expenditure; an R&D-focused expenditure; and an actual expenditure. If an activity does not meet all four of those criteria, then its expenditures will be judged to be not comparable to an actual U.S. Federal Government expenditure for AI R&D.

C. Contextualize the Assessment

If an announced activity satisfies all four criteria, then we will have the information necessary to provide an estimate of the portion of the associated expenditure that is comparable to U.S. Federal AI R&D. Estimated expenditures provided without context and caveats can be misleading. Every assessment and associated expenditure estimate should clearly detail its associated unknowns and provide at least one relevant data point for context.

For example, to contextualize the amount of money *reportedly* being spent in China on AI, it is instructive to keep in mind the total amount of money spent on R&D across all topics and all levels of society. In 2017, total R&D expenditures in China, by companies and the government, were $260 billion (National Bureau of Statistics of China n.d.). Assuming that the 2017 R&D figure is approximately correct for 2018, the nearly $15 billion AI development fund announced by the Tianjin Municipal Government would represent roughly 6 percent of China's total R&D annual expenditures spent by a single

local government in a single topic area—that is, *if* the Tianjin fund were an R&D expenditure, focused solely on AI, and spent all in 1 year. Since it is unlikely that a single Tianjin activity represents 6 percent of national expenditures, the $15 billion figure should be approached with skepticism, while the latter three assumptions are investigated.

4. Conclusion

This document has detailed the tentative framework that STPI is using to analyze open source data on Chinese non-defense R&D on AI. The primary purpose of this framework and our future analysis is to test the hypothesis that information in Chinese government documents and reported in the Chinese media is too poorly defined—in terms of timing, sources, and purpose—to support credible comparisons between U.S. Federal and Chinese central government expenditures on non-defense AI research and development. Many potential pitfalls exist when attempting to make such a comparison, and we recognize that we may not have fully addressed them all. Due to data availability, this framework is currently scoped to investigate only activities supported by a subset of Chinese funding mechanisms for R&D, i.e., openly competed expenditures for non-defense activities. This framework is not intended to estimate China's total expenditures on non-defense R&D for AI.

We are applying this approach to a corpus of reported Chinese activities that support AI. The results of our analysis will be the subject of a future report. The framework detailed here may evolve as the analysis progresses and we discover more issues that need to be addressed. We hope that this tentative framework may be a useful starting point to better understand China's expenditures on AI R&D more broadly or other emerging industries.

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[2] The fund has a target capitalization of 100 billion RMB. This reference states that the fund will be worth $16 billion; however, using OECD's 2017 exchange rate of 6.62 RMB to $1, the fund is valued closer to $15 billion.

Abbreviations

AI	Artificial Intelligence
NCSES	National Center for Science and Engineering Statistics
NITRD	Networking and Information Technology Research and Development
NSF	National Science Foundation
OMB	Office of Management and Budget
R&D	Research and Development
STPI	Science and Technology Policy Institute