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De-monopolization Toward Long-Term Prosperity in China

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De-monopolization Toward Long-Term Prosperity in China

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Abstract

During the past decade, the average Chinese earns roughly 9 times less and is 10 times less productive than the average American at purchasing power parity. Current consensus attributes large differences in output per worker to differences in total factor productivity (TFP). Evidence suggests that most of the US-China TFP differences lie in the inefficiency of China's domestic-oriented service and agricultural sectors. This paper focuses on (1) the evidence of monopoly rights and its influence on work practice improvement at China's firms and plants and (2) the evidence that policy arrangement there has encouraged more competition in merchandise manufacturing and heavy industries while barriers to market access remain high against new firms in the domestic market (especially in services). A numerical experiment is provided, which suggests that China can enhance long-term income per capita by a factor of 10 largely through TFP gains by implementing reform to weaken protection of monopolies and encourage entry in all industries.

JEL Classification Numbers: O11, O43, O47

Keywords: Aggregate Productivity, Total Factor Productivity, Competition, Monopoly Rights

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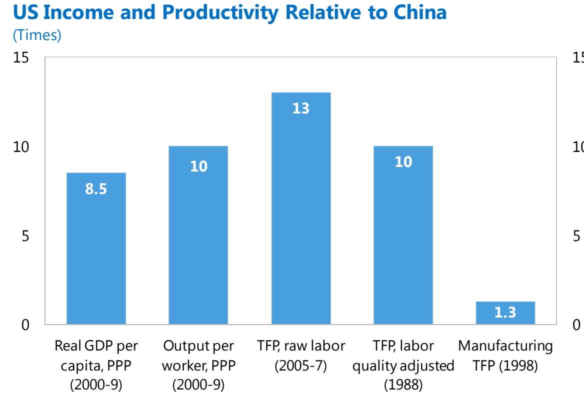
I. INTRODUCTION

During the past decade, the average Chinese earns approximately 9 times less than the average American and the typical Chinese worker is less productive than her American counterpart by a factor of roughly 10 when measured at purchasing power parity (PPP).[1] What accounts for such large differences in income per capita between China and the United States? Current consensus in growth and development accounting mainly attributes large differences in output per worker between rich and poor countries to differences in total factor productivity (TFP) while assigning a significantly lesser role to gaps in physical and human capital stocks.[2] Conclusions based on cross-country micro-data approach to productivity measurements and comparisons also confirm these results (see Baily and Solow, 2001). In the case between China and the U.S., Hall and Jones (1999) estimate that Chinese output per worker would be around half of output per worker without the large difference in TFP alone.[3]

US Income and Productivity Relative to China



Sources: Penn World Table 7.0, Hall and Jones (1999), Hsieh and Klenow (2009) and author's calculation.

The gap between measured U.S. and China's aggregate TFP levels is approximately 13 times in favor of the United States.[4] Differences between U.S. and China's manufacturing TFP levels appear much smaller at about 1.3-1.5 times (Hsieh and Klenow, 2009). Thus, even accounting for measurement errors, most of the differences in aggregate productivity and therefore living standards between China and the U.S. have to be rooted in the inefficiency in the non-manufacturing—mostly domestic-oriented services and agriculture—sectors. In growth terms, He, Zhang, Han, and Wu (2011) find that China's nontradable TFP growth has been around 2.2-2.5 percent per annum lower than manufacturing-heavy tradable TFP growth during 2001-10.

A stream of research papers have focused on what accounts for such large TFP differences across countries. Systematic resource misallocation is a key theme. Restuccia and Rogerson (2008) and Hsieh and Klenow (2009), for example, find that misallocation of resources across firms can have important effects on aggregate TFP. Focusing on China, India and the

[1] Based on 2000-2009 real GDP per capita at purchasing power parity (PPP), chain method, and real GDP per worker at PPP from the Penn World Table version 7.0.

[2] See, for example, Klenow and Rodriguez-Clare (1997), Hall and Jones (1999), Easterly and Levine (2001), Jasso, Rosenzweig, and Smith (2000), Hendricks (2002), Caselli (2005), and Hsieh and Klenow (2010).

[3] Measured with labor quality-adjusted TFP gap and assuming fixed aggregate capital and human capital stock.

[4] The TFP gap size is based on 2005-07 data, after adjusting capital stock to PPP, but not adjusted for labor quality. Measured productivity levels for China could be distorted by various subsidized factor prices (capital, land and energy, as well as intellectual property).

U.S., Hsieh and Klenow (2009) use micro-level data to quantify large manufacturing total factor productivity loss from resource misallocation in the periods before China joined the WTO. Viewed from a static, standard monopolistic competition model, they show that moving to "U.S. efficiency" would increase China's manufacturing TFP by about 30-50 percent based on 1997-08 data. The literature offers other specific mechanisms by which resource misallocation could lower aggregate TFP, such as labor market regulations (see e.g., Hopenhayn and Rogerson, 1994; and Lagos, 2006), deficiency in capital allocation vis-a-vis managerial talents (e.g., Caselli and Gennaioli, 2003; and Buera and Shin, 2008), and vested interests' ability to block firms from introducing better work practice (Parente and Prescott, 1997 and 1999). Lewis (2004a and 2004b) offers evidence from 13 emerging and advanced economies linking institutions and policy arrangements to subpar performance of industry- and economy-wide aggregate TFP. The overarching lesson from all this: The main obstacles to productivity growth and economic progress in poor countries are the many policies that limit market competition.

The plan of the paper is as follows: To explain large discrepancies in per capita income between China and the U.S., this paper (1) focuses on the evidence of monopoly rights and links it to work practice in China and (2) the evidence that policy reform adopted by China encourages more competition in merchandise manufacturing and heavy industries through external trade while barriers to market access remain high against new domestic and foreign firms in the domestic market (especially in services). Resistance to better work practice, which surfaces through large scopes of rent seeking and is more prevalent in some domestic-oriented (nontradable) industries, is likely to be a significant source of impediments for China's long-term economic prospects.

The paper then explores the extent to which reforming the "monopoly rights" policy arrangement that China currently employ can enhance long-term income per capita using a general equilibrium model with strategic game developed by Parente and Prescott (1999). The defining feature of the model is the existence of state protection of vested interest groups and industry insiders that can undertake strategic actions against entering "high-technology" firms. The time path of aggregate productivity levels is highly correlated with the economic policy arrangements countries choose, specifically regarding the ability and incentive of organized forces in each society to resist the adoption of superior technology and persist in inefficient usage of currently operating ones. The principal insight from the stylized model is that these long-term gains are made through improvement in TFP rather than factor accumulation (e.g., through high fixed asset investment growth) *per se*; and these gains are made by shifting away from monopoly rights to the free enterprise policy arrangement. The result should facilitate a policy discussion about the direction of ongoing corporate and financial reforms in China today.

The model, once calibrated to China and U.S.'s growth facts, can capture discrepancies in GDP per capita between the two economies (at PPP) reasonably well. The discrepancy in GDP per capita is mainly accounted for by differences in TFP, which is consistent with cross country work in growth and development accounting. Specifically, the model predicts that China's long-term GDP per capita could be higher by a factor of 10 under the "free enterprise" arrangement than under the protected "monopoly rights" arrangement that approximates the economy well today. The increase in per capita income of this nature is driven by the increase in China's TFP by a factor of around 3½. Over time, physical capital accumulation, as well as education and skill acquisition, will follow as their rates of return rise on the back of higher TFP. Assuming that China's reproducible capital share remains at around 0.45, China's GDP per capita would be about 10 times larger in the long run as a result.

The model also predicts that *unit price* of the goods and services produced in the sectors with barriers to entry relative to that of goods and services produced in the competitive sector is about 3¼ times higher in China under "monopoly rights" than in the rich country with "free enterprise." This is roughly the ratio of the prices of investment goods to consumption goods across rich and poor countries in the Summers and Heston data (3-4 times).

The model's results also suggest that ongoing reform efforts should target at productivity improvement rather than factor accumulation *per se*. Drawing lessons from the extraordinary success in Chinese manufacturing exports, China should persist with reform to weaken protection and encourage entry in all industries. Competitive pressure from multinationals and new domestic firms will help transform work practice across Chinese firms.[5] More products and services will be produced at more affordable prices. Wages will rise and converge across sectors. More firms operated in China will innovate and export best practice to the world. Chinese workers and households will be made better off as rent seeking activities fade away. As a result, large international income gap between China and leading industrialized countries will eventually be eliminated. In the long run, Chinese will be much more prosperous than otherwise.

The rest of the paper proceeds as follows. Section II presents salient evidence of protected monopoly rights and discusses work practice at Chinese firms. Section III lays out the model. Section IV outlines model's calibration and reports numerical findings. Section V concludes the paper.

II. Evidence of Monopoly Rights and Work Practice at Chinese Plants

Published empirical findings on industry and firm level productivity in China are rare and centered on the manufacturing sector. Existing industry-level accounts of productivity in China's nonmanufacturing sectors are largely based on case studies done by the McKinsey Global Institute (MGI). He, Zhang, Han, and Wu (2011) offer an insight into the large discrepancy between tradable (dominated by manufacturing) and nontradable TFP growth in China during the past decade, but lack of data prevents an explicit calculation of industry-level TFP growth for nontradables.

[5] The reform efforts may need to be properly sequenced to manage resistance from vested interest groups, but this is beyond the scope of the paper.

China's manufacturing sector has enjoyed exceptionally fast productivity growth in the decade before and after China's entry into the WTO.[6] This manufacturing productivity boom follows the gradual application of *zhengqi fenkai* policy, which formally separates government functions from business operations. The government first applies the policy with consumer goods industry and then to high-technology and heavy manufacturing in preparation for global competition (Woetzel, 2008). After the entry into WTO, favoritism reserved for large state-owned firms has been fading; and private domestic firms are at the forefront of the rapidly changing business landscape. State-owned manufacturing plants, which ran at 40 percent less TFP than private domestic plants started to exit, their numbers falling from 29 percent in 1998 to only 8 percent in 2005 (Hsieh and Klenow, 2009). *Regardless of ownership type,* exit means survivors now run plants at a much higher average TFP. Furthermore, the rise in market competition largely reflects the exits of SOEs, mostly small- and medium-sized, and the rapid growth of private firms (Conway, Herd, Chalaux, He, and Yu, 2010). With improved SOE governance, SOEs are becoming more efficient and behaving more like private firms.

Examples of successful cases abound in industries that face competitive pressure from the global market. To cite a few, the Chinese communications equipment industry has improved its quality and gained market acceptance in advanced economies. China's solar and wind power industries are using new manufacturing techniques to create more efficient solar panels and are already supplying sophisticated, vital components for the industry worldwide (Orr and Roth, 2012).

Successful industries have benefited from government policies, notably access to factors of production at subsidized prices, market access barriers and those that encourage domestic purchasing of goods and services (to guarantee revenue pools). Nevertheless, it would be a mistake to attribute the stride made in manufacturing productivity simply to government support as many government-backed projects have not been successful.

Instead, the success stories behind Chinese manufacturing productivity growth performance seem to fit well with other cross-country case studies. Evidence from case studies from 13 emerging and advanced economies reveals that institutions and policy arrangements can potentially result in subpar performance of industry- and economy-wide aggregate TFP[7] (Lewis, 2004a and 2004b). The main obstacles to productivity growth and economic progress in poor countries appear to be the many policies that limit competition. The success of China's manufacturing sector confirms a clear link between pressure from global competition and powerful incentives and ability to adopt better technology and improve work practice.

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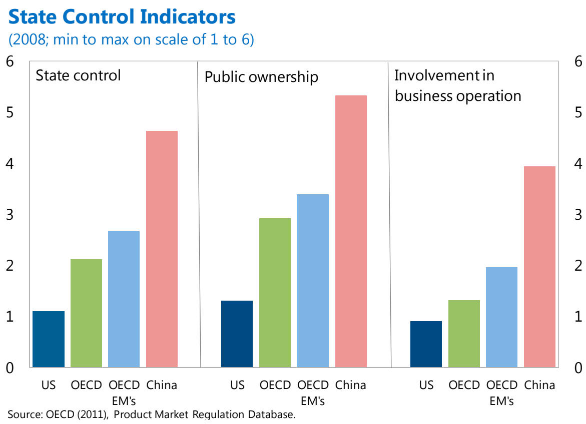
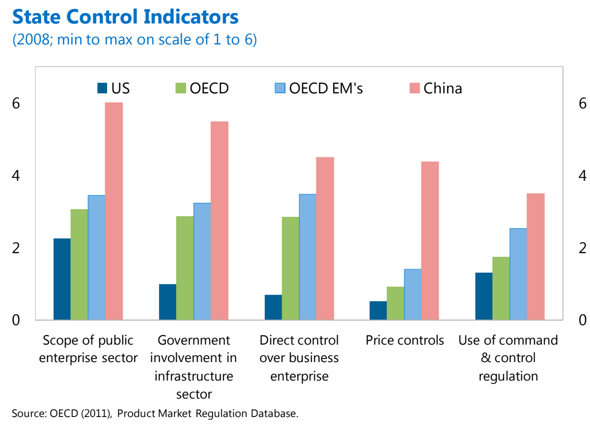
[6] He, Zhang, Han, and Wu estimate annual tradable (mostly manufacturing) TFP growth at between 4.6-5.4 percent between 2002 and 2007. Guo and N'Diaye (2009) estimate of manufacturing TFP growth is at 6½ percent per year on average between 2002-07. Bosworth and Collins' (2007) industry TFP growth during 1993-2004 averages 6.2 percent per year.

[7] The countries covered are Australia, Brazil, France, Germany, India, Japan, the Netherlands, Poland, Russia, South Korea, Sweden, the UK, and the United States. Each study analyzes 6 to 13 industries and compares their performance with that of the same industries in a subset of other countries. These are detailed studies of individual businesses spanning "state-of-the-art auto plants to black-market street vendors."

The case of China's service (nontradable) sectors, on the other hand, strongly suggests that the lack of pressure from competition may be the cause for its poor relative performance.





Despite increasingly robust competition over the years and substantial improvement in business regulatory environment, influential partners, protection from competition and extensive pricing power continue to characterize the environment in China's business sector today (World Bank, 2011 and Conway, et al., 2010).[8] China's economy is still dominated by state and state-partner monopolies, which are shielded from meaningful competition in the domestic market, for instance, by state support, regulations,[9] licensing and technology sharing rules. These firms tend to be large, capital-intensive and well-connected, concentrated in "strategic" and "pillar" sectors, and benefit from subsidies as well as preferential access to finance, land and other resources. They are not confined to electricity generation and distribution, natural gas, and water, but outside of the industrial sector, such as banking, telecommunications and the media.[10] Subsidization of these firms can work effectively to promote employment growth, deter entry and discourage more productive work practices. Finally, murky ownership rights, unsystematically kept titles, financial records, collateral and pledges increase due diligence costs and work as barriers against potential entrants, especially those that are smaller or not homegrown.[11]

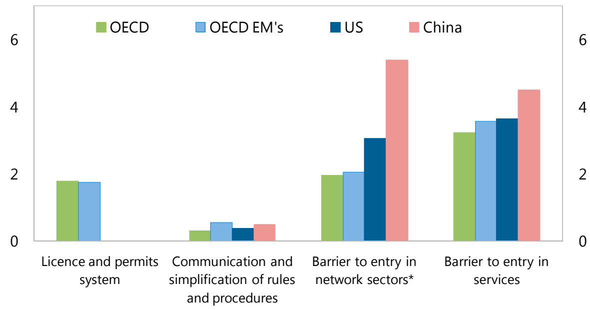
[8] Conway, et al. (2010) attributes this fast-paced improvement to reforms in the new company law and the new bankruptcy law, which help reduce the time needed to register or close a business, increase the recovery rate from bankruptcy, and reduce the minimum amount of capital needed to start a firm.

[9] For instance, services, such as legal and accounting, maritime and air transport, and postal sectors could benefit from foreign service providers through higher FDI if restrictions on form of ownership and maximum equity stake, geographic scope and line of business restrictions as well as minimum capital requirement (not equally imposed on domestic competitors) are removed (OECD, 2009). Currently, much of the service sector FDI goes into real estate and banking, which is gradually opening up.

[10] Despite the stated intention to open up these sectors to private investment, these sectors are still dominated by public enterprises.

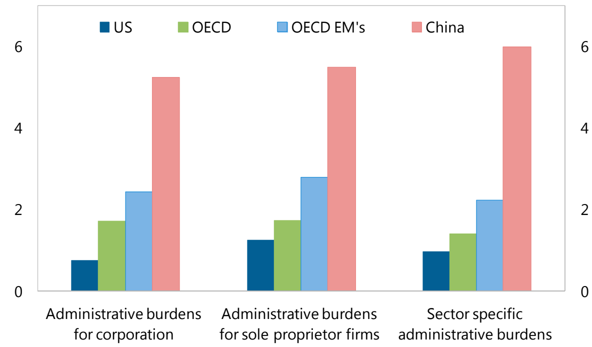
[11] World Bank (2011) ranks China 79th out of 183 economies for overall "ease of doing business," and rates China unfavorably on obstacles to "starting a business" (rank 151st out of 183 economies), "dealing with construction permits" (rank 181st) and "investor protection" (rank 93rd).

Barriers to Entrepreneurship Indicators
(2008; min to max on scale of 1 to 6)



Source: OECD (2011), Product Market Regulation Database.
* Network sectors, amonng others, include electricity generation and distribution, natural gas and water, telecommunications, banking and the media.

Barriers to Entrepreneurship: Administrative Burdens
(2008; min to max on scale of 1 to 6)



Source: OECD (2011), Product Market Regulation Database.

Even in today's highly competitive manufacturing sector, there is evidence that policy arrangement continues to obstruct improvement in work practice and productivity as late as around mid-2000s. There was significant waste even at high-productivity plants run by multinational industry leaders, which reduces profits by 20-40 percent at some plants (Aminpour and Woetzel, 2006). The inefficiency arises not from weak profit motive on the part of the plant managers, but can be partly attributed to the way foreign firms tend to gain market access; that is, via partnership with large state-owned enterprises or through business acquisitions. While this process secured "the right locations, the right government relationships, the right joint ventures, [which] shut out other [players] from this market" for years if not a decade, multinationals have inherited "hard to change legacy work processes, employee mind-sets [as well as] manufacturing approaches" (Hexter and Woetzel, 2007). In some cases, introducing a procurement process practiced in these multinationals' established home markets—an "innovation" in China—could generate substantial savings for their operations in China. Nevertheless, many multinationals have been able to run plants less efficiently than in Europe and the U.S. and still "come out way ahead" with the advantage of relatively low costs of labor and intermediate inputs sourced locally. In this way, high profit margins and business growth can undercut the incentive to change work practice and improve operational efficiency.

To adapt best practice to local market conditions and execute superlative operating performance, a business would require reliable markets and customers data, quality suppliers, efficient distribution network, for instance, which are not readily available in China. These impediments clearly indicate relatively poor service sector productivity, including financial services (MGI, 2006). Manufacturing productivity, already high and close to U.S. level, is likely to improve further provided quality and cost of service inputs improve.

These case studies help shed light on the underlying cause for TFP differences across countries. They motivate a case that incentives and abilities of existing firms to dictate industry work practice can be an important mechanism by which resources are misallocated. State protection makes cost of entry by other foreign and domestic firms prohibitive, in turn generating immense value to these monopoly rights. Their lessons seem to be consistent with the theory proposed by Parente and Prescott (1999), which holds that state actions to prohibit or distort firms' incentives to change work practice tend to be irrelevant unless the state also protects the industry from outside competition.

III. The Model

To measure potential gains from demonopolization, this paper relies on the framework and model of Parente and Prescott (1999). This relatively simple, closed-economy model has a strategic mechanism that allows vested interests to impede economic progress. The vested interest groups have valuable monopoly rights that are tied to existing production technology. In every period, no take-up of better technology (or work practice) as well as inefficient use of existing one is a possible outcome of a strategic game between two players: the protected coalition of factor suppliers and a potential entrant who has to pay to overcome entry resistance.

The model has two production sectors utilizing constant returns to scale technologies with no fixed cost under the Dixit-Stiglitz-Spence commodities structure. Industries are competitive; though they need not be private. There are economic rents in the model.

Under the "monopoly rights" arrangement, coalition members can set up firms with protected rights to operate existing technology. Because of these rights, every firm in the industry employing that technology must hire coalition members. The coalition's objective is to maximize per-member income by setting membership size, compensation and work practice level (or productivity). In the model, coalition size acts as a deterrent to entry.

Since these protected rights have value, potential entrants must pay to overcome resistance to enter the market. If entry occurs, then the entrant uses a superior technology. In the game, the return to entry depends on the strength of state protection as well as coalition size. When protection is weak, entry occurs because the minimum coalition size necessary to deter entry is too large to provide adequate compensation to recruit and retain members. As a result, firms in every industry always end up adopting better work practice. At the other end of the spectrum, when protection is strong, entry cannot occur at all and every firm operates the current, inferior technology. Interestingly, when state protection is not too strong, the minimum-deterrent coalition size is larger than the number of members required to produce competitive equilibrium output. In this case, firms not only fail to adopt better work practice, but they also operate the existing inferior technology inefficiently. This is the relevant case for our analysis of China.

Under the "free enterprise" policy arrangement—or equivalently, a demonopolized arrangement—there is no coalition to deter entry and all agents act in a perfectly competitive way.

A. Model's Environment

The model economy consists of three sectors: household, agriculture, and industry. In any given period, a household can be one of the three: an agricultural worker, an industrial worker, or an industrial entrepreneur who adopts a technology to produce goods and services.

Let $t \in \{1,2,3,...\}$ denote the time period, and $i \in [0,1]$ the type of industrial goods produced. There are $i+1$ goods in this economy, industrial (differentiated) and agricultural goods. The *household sector* consists of a measure N of infinitely-lived atomless households. At every t, a household is endowed with one unit each of labor and land services. At every t, each household values only agricultural goods, a_t, and differentiated (industrial) goods, x_{it}. Households do not value leisure. They want to smooth consumption over time and derive enjoyment from variety. A household's preference is represented by the following strictly concave utility function:

$$U(a_t, x_{it}) = \sum_{t=0}^{\infty} \beta^t \left\{ \left[\int_0^1 (x_{it})^\eta \, di + \mu \cdot (a_t)^\eta \right]^{\frac{\theta}{\eta}} - 1 \right\} \Big/ \theta, \tag{1}$$

where $\beta \in (0,1)$ is the subjective discount parameter measuring the household's degree of time preference; $\mu > 0$ is the weight parameter assigned to agricultural goods in the utility function; $\eta < 0$; and $\theta < 1$.

There are three technologies in the *industrial sector*—low, medium and high efficiency levels, π_k, ranked according to the amount of labor input requirements per unit of output, and indexed by $k \in \{0,1,2\}$. An entrepreneurial household forming an industrial firm can adopt any technology without incurring any firm-specific investment. Each industrial firm's production function, $G : \Re_+ \to \Re_+$, is constant returns to scale and uses only labor services:

$$X_{it} \le G(N_{it}) = \pi_k N_{it}, \tag{2}$$

where N_{it} is the labor input, X_{it} is the output, and $\pi_0 < \pi_1 < \pi_2$.

In the *agricultural sector*, there is a constant returns to scale, nested CES production function in which the mix of the intermediate industrial goods is treated as a substitute for the composite labor-land input:

$$A_t = \Im(X_{a,it}, N_{a,t}, L_{a,t}) = \left[\psi \cdot \left(\int_0^1 (X_{a,it})^\sigma di \right)^{\rho/\sigma} + (1-\psi) \cdot \left(N_{a,t}^{\alpha} \cdot L_{a,t}^{1-\alpha} \right)^\rho \right]^{1/\rho}, \tag{3}$$

where $\psi, \alpha, \rho \in (0,1)$, $\sigma < 0$; both ψ and α are share parameters;[12] ρ determines the degree of substitutability among inputs;[13] $X_{a,it}$ is the differentiated goods input of type i, $N_{a,it}$ and $L_{a,it}$ the labor and land services inputs, respectively.[14]

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[12] The former is the share of expenditure on intermediate (differentiated) goods in total expenditures on intermediate and labor-land composite inputs. With Cobb-Douglas production function (i.e. CES where the

(continued…)

B. "Monopoly Rights" Arrangement, its Equilibrium, and Some Intuition

In the model, monopoly rights are only relevant to the industrial sector. The agricultural (which may also be thought to include some services) sector is perfectly competitive.[15] In each industry (under *X*), any individual can avail himself of the π_0 technology, and there is free entry and exit for those operating with the π_1 technology. That is, entry obstruction applies only to the π_2 technology firms.

Workers and entrepreneurs in the industrial sector can form coalitions. Protected monopoly rights are extended *only* to existing firms employing π_1 technology. These rights are protected throughout the life of the coalition, the length of which depends on the ability to provide surplus rents to its members. Thus, the initial state of a differentiated good industry i is the initial size of the coalition in that industry. All industries have the same state.

For any industrial firm that employs the π_1 technology, the coalition in that industry has the rights to limit its membership size, set the compensation (or wage) rate, and dictate work practices. The coalition dictates work practices by determining the productivity level $\pi_x \leq \pi_1$ of any π_1-capable firm. A potential entrant employing the π_2 technology has to pay entry cost to overcome the resistance associated with the protection of these valuable monopoly rights. The entry cost is the compensation of $N\phi$ (measured in units of labor services), where $\phi > 0$ represents the strength of state protection.[16] The larger the market size, the more a new firm should be willing to pay to enter.

C. The Monopoly Rights Equilibrium

Next, I describe the entry game of an industry, define the symmetric *no-entry steady state* equilibrium, and list the necessary and sufficient conditions for that steady state.

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elasticity of substitution between two inputs is unity), the latter is the share of land rental income in total income, which is the sum of land rental and agricultural wage incomes.

[13] Since $0 < \rho < 1$, the degree of substitutability is between Cobb-Douglas (unit elasticity of substitution, i.e. $\rho = 0$) and perfect substitution (infinite elasticity, i.e. $\rho = 1$).

[14] The assumptions $\eta < 0$ and $\sigma < 0$ are made to ensure that household demand for the i^{th} differentiated industrial commodity as well as the farm sector's demand for each differentiated input are price inelastic. This simplifying assumption is made to ensure that the equilibrium price under "monopoly rights" arrangement will be the maximum entry-deterrent price.

[15] Examples of these are home or market production of goods and services such as bicycle repair shops, hair salon, restaurants, etc. in developing countries.

[16] The assumption that entry cost increases in proportion of population size (which is also the size of the coalition) also ensures that all results are population-size invariant.

There is an equilibrium for this strategic game.[17] An equilibrium can be either that of "no-entry" or with entry in every industry in steady state. An equilibrium is characterized by utility maximization in the household sector, profit maximization in the agricultural sector, market clearing, and a subgame perfect equilibrium to the game in each industry i. This is to ensure that the equilibrium solution obtained through agents' utility and firms' profit maximization is consistent with players' strategic behavior and that non-credible threats are not exercised in equilibrium.

In this game, the two players take as given industry i's output demand and the wage in the competitive agricultural sector. Each industry is small relative to the economy and so output demand is taken parametrically, and players' behavior has no bearing on industry demand or agricultural wages.

First Stage (Coalition size decided):
(*1*) In a non-cooperative fashion, each member of the coalition decides voluntarily whether to remain a member and work in industry i in the current period or leave the coalition for the agricultural sector. Therefore, if there are *both* remaining workers and leavers, then everyone must earn the agricultural sector wage.

(*2*) The coalition decides how many new members will be admitted. Let $N_{x,i}$ denote the measure of coalition members in industry i in the period. Then $N_{x,i}$ is equal to the number of remainders plus joiners less leavers.

Let $w_x(N_{x,i})$ be the wage paid a coalition member in industry i, which is a function of $N_{x,i}$, and w_a be the agricultural wage. In equilibrium, $w_x(N_{x,i}) \geq w_a$.

Second Stage (Entry decision): The potential entering firm with the π_2 technology decides whether to invest $N\phi$ and overcome resistance from existing firms.

Third Stage (Coalition's response, conditional upon entry):
(*1*) If the potential entrant does not pay to enter, then the coalition chooses a productivity level $\pi_x(i) \leq \pi_1$ for existing firms and the wage rate $w_x(N_{x,i})$.

(*2*) If the entering investment is made, then the coalition chooses $\pi_x(i)$ and $w_x(N_{x,i})$, and make available its workers to the entrant and competing firms. This is required for subgame perfection. The entrant chooses output price p_E non-cooperatively.

[17] A brief outline of the existence proof is provided in Parente and Prescott (1997).

Conditional on entry, therefore, there is price competition where the entrant has a marginal cost w_a/π_2 and can produce any quantity demanded by consumers.[18] The coalition has zero marginal cost up to the capacity constraint $\pi_1 N_{x,i}$ because its members are committed to working in that industry for the period.

Let the agricultural good be the numeraire good for the economy, and let p_i denote the price of differentiated good i in units of agricultural goods.

Definition (Steady State): The system is in a steady state when there is no change in the membership size of the coalition in each industry, i.e. $N_{i,t} = N_i, \forall i$. Moreover, in a *symmetric* steady state with no entry, $p_i = p, \forall i$.

This simplifies the analysis to a representative industry in the steady state. As long as there is no adoption of the π_2 technology (i.e. no entry), the equilibrium outcomes are the same in all periods.

Let $F : \Re_+^3 \to \Re$ be the agricultural sector production function in the steady state to be derived from $\Im$; r denote the rental price of a unit of land; N_a be the measure of agricultural-worker households (or equivalently in equilibrium, labor service input in the agricultural sector); N_x be the measure of industrial worker households (or equivalently in equilibrium, labor service inputs in the industrial sector); h be household type categorized according to worker type, where $h = a$ denotes agricultural-worker household and $h = x$ for industrial-worker household; (a_h, x_h), for $h \in \{a, x\}$, be household consumption allocations of agricultural and industrial goods; (A, X_a, N_a, L_a) be agricultural sector allocations; (X, N_x) be representative industry allocations; and π_x be productivity level.

Definition (No-entry steady-state "monopoly rights" equilibrium): A *no-entry steady-state "monopoly rights" equilibrium* is a list of prices, (p^M, w_a^M, w_x^M, r^M), allocations $(A^M, X_a^M, N_a^M, L_a^M; X^M, N_x^M; a_a^M, x_a^M, a_x^M, x_x^M)$, and productivity π_x^M such that:[19]

(A) Farm sector profit is maximized. Given the price system (p^M, w_a^M, r^M) and that in steady state,

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[18] Marginal cost of firms with π_0 or π_2 technology is:

$MC_{\pi_2,\pi_0} = \dfrac{\partial TC}{\partial X} = \dfrac{\partial (w_a N_x = w_a X/\pi_{0,2})}{\partial X} = \dfrac{w_a}{\pi_{0,2}}$. That is because a worker required for producing an *additional* unit of output using these two technologies only needs be paid agricultural wages since he is not in the coalition.

[19] The M superscripts represent the equilibrium values of variables under "monopoly rights."

$$A = F(X_a, N_a, L_a) \equiv \left[\psi X_a^\rho + (1-\psi)\cdot\left(N_a^\alpha L_a^{1-\alpha}\right)^\rho\right]^{1/\rho}, \tag{4}$$

the representative agricultural firm picks (X_a^M, N_a^M, L_a^M) such that

$$p^M = F_X(X_a^M, N_a^M, L_a^M), \tag{5}$$

$$w_a^M = F_N(X_a^M, N_a^M, L_a^M), \tag{6}$$

$$r^M = F_L(X_a^M, N_a^M, L_a^M). \tag{7}$$

(B) Household utility is maximized. Given the price system (p^M, w_a^M, r^M), the following necessary conditions must hold for a household of worker type $h \in \{a, x\}$:

$$p^M = \frac{\left(x_h^M\right)^{\eta-1}\left(a_h^M\right)^{1-\eta}}{\mu}, \tag{8}$$

and

$$a_h^M + p^M \cdot x_h^M = w_h^M + r^M. \tag{9}$$

(C) Market clearing condition. The markets for differentiated goods, agricultural goods, labor, and land must clear:

$$\sum_h N_h^M x_h^M + X_a^M = X^M, \tag{10}$$

$$\sum_h N_h^M a_h^M = A^M, \tag{11}$$

$$N_a^M + N_x^M = N^M, \tag{12}$$

$$L_a^M = N^M. \tag{13}$$

(D) Subgame perfection, which gives the following necessary conditions; that is, the minimal-deterrent entry condition, the per-member income maximizing conditions, and the entry-deterrent condition:

$$\max_p\left[\left(p - \frac{w_a^M}{\pi_2}\right)\cdot\left(D(p) - \pi_1 N_x^M\right)\right] = w_a^M N^M \phi, \tag{14}$$

where $D(\cdot)$ is quantity demanded for differentiated goods,

$$p^M = \frac{w_a^M}{\pi_0}, \tag{15}$$

$$w_x^M = \frac{D\left(w_a^M / \pi_0\right)}{N_x^M} \cdot \frac{w_a^M}{\pi_0}, \tag{16}$$

$$\pi_x^M = \frac{D\left(w_a^M / \pi_0\right)}{N_x^M}, \tag{17}$$

and

$$w_x^M \geq w_a^M . \tag{18}$$

∎

Conditions (4)-(18) are both necessary *and* sufficient for a no-entry steady-state "monopoly rights" equilibrium.

Condition (4) gives steady state equilibrium value of output from the free-entry perfectly competitive agricultural sector. Conditions (5)-(7) state that (real) factor input prices equal their respective marginal products. Condition (8) states that the ratio of differentiated good and agricultural good prices is equal to the ratio of the respective marginal utilities of their consumption. Condition (9) states that households exhaust their budgets in equilibrium. Conditions (10)-(13) state that quantity supplied must equal quantity demanded in every market in equilibrium.

Condition (14) states that, in equilibrium, the entrant will pick an output price such that the investment it has to make to overcome resistance and enter the market will be exactly the maximum profit generated from residual demand; hence, the minimal-deterrent entry condition.[20] Notice that in every industry i, coalition workers at the existing π_1 technology firms supply output as efficiently as they can and produce the maximum level of output at $\pi_1 N_{x,i}$. Confronted by an entering firm with better technology, the coalition maximizes per member income by choosing $\pi_{x,i} = \pi_1$ to *minimize* the entrant's profit, given the price set by the entrant. They would set work practice level to maximum whenever entry threat prospects are credible.

[20] The first term inside the argument maximum operator is the difference between output price and marginal cost per unit of output. The second term is the residual demand, unsatisfied by the competing π_1 technology firms employing coalition members.

Condition (15) states that the coalition will set work practices and wage rate so that equilibrium price equals marginal cost at every competing π_0 technology firms.[21] The combined choice of work practices and wage rate set by the coalition must be consistent with an equilibrium condition that nominal wage paid to a worker at a π_0 technology firm has to equal her marginal revenue product.

Condition (16) states that equilibrium profit is zero at every π_1 technology firm as total revenue equals total cost, which is to say wages paid to coalition members equal their marginal revenue product. Condition (17) is simply a market clearing condition.

D. The Competitive Equilibrium

In this particular economy, there exists a unique competitive equilibrium.

Definition (Competitive Equilibrium):[22] A *steady-state competitive equilibrium* is a list of prices, $(\hat{p}, \hat{w}_a, \hat{w}_x, \hat{r})$ and allocations $(\hat{A}, \hat{X}_a, \hat{N}_a, \hat{L}_a; \hat{X}, \hat{N}_x; \hat{a}_a, \hat{x}_a, \hat{a}_x, \hat{x}_x)$ such that:

(A) The lists $(\hat{p}, \hat{w}_a, \hat{w}_x, \hat{r})$ and $(\hat{A}, \hat{X}_a, \hat{N}_a, \hat{L}_a; \hat{X}, \hat{N}_x; \hat{a}_a, \hat{x}_a, \hat{a}_x, \hat{x}_x)$ satisfy conditions (4)-(13) above, and

(B) $$\hat{p} = \frac{\hat{w}_x}{\pi_2}, \tag{19}$$

$$\hat{X} = \pi_2 \hat{N}_x, \tag{20}$$

$$\hat{w}_x = \hat{w}_a. \tag{21}$$

∎

[21] If equilibrium price exceeds marginal cost of π_0 technology firms, there will be positive profit associated with using π_0 technology and more π_0 technology firms producing differentiated goods, and fewer coalition workers will be employed, which is inconsistent with the already chosen coalition-member-compensation-maximizing $N_{x,i}$. If the marginal cost of π_0 technology firms exceeds equilibrium price, then all π_0 technology firms will perish, shedding workers as a result. These workers will either have to work in the farm sector or for π_1 technology firms and become members of the coalition by default. More members will dilute income per share of coalition members, *ceteris paribus*. This is also inconsistent with the compensation-maximizing choice of $N_{x,i}$.

[22] Uniqueness of the competitive equilibrium is straightforward to prove. Preferences are strictly concave and locally nonsatiated. If there is a competitive equilibrium, then its uniqueness is guaranteed. The First Welfare Theorem argument can be used to prove existence.

Conditions (4)-(13) and (19)-(21) are necessary and sufficient for a competitive equilibrium. Condition (19) states that equilibrium differentiated output price equals marginal cost a competitive firm faces since firms in this sector employ π_2 technology. Condition (20) states that in equilibrium differentiated goods are produced with π_2 technology. Condition (21) states that wages are equalized across sectors.

Let Y denote total value added or aggregate production in the model economy. The magnitude of Y can be derived by any of the three equivalent methods: (1) *Y* as total value added, i.e. sum of final products less intermediate goods in each sector (*A* and *X*), as above; (2) *Y* as total income, i.e. sum of wage income in two industries and land rental income; and (3) *Y* as total products available for final use. This is made clear in the computation in Section IV. Then, since X_a is the intermediate goods used in sector *A*, $Y^M = \left(A^M - p^M X_a^M\right) + p^M X^M$ and $\hat{Y} = \left(\hat{A} - \hat{p}\hat{X}_a\right) + \hat{p}\hat{X}$.

IV. Calibration and Findings

First, the empirical counterparts of sectors *A* and *X* need to be specified. Then, preference, industrial sector technology, and farm sector parameters are calibrated to replicate the key "stylized" relations among model aggregates. The calibrated model will then be ready to measure the potential gains from eliminating monopoly rights in China.

The defining feature of the *A* sector in the model's "monopoly rights" arrangement is that there are *no* protected "monopoly rights" connected with the currently operating technology for producing this good. The delineation may not be so sharp in the real world. Nevertheless, the most significant empirical counterpart for *A*'s product in less-developed and developing countries should consist of agricultural goods, as well as household services and production. For China during 2000-09, the following sectors are assigned to *A* (largely no barrier to entry and tend to be labor-intensive): primary industry, household services and production, wholesale and retail trade, accommodation and catering, real estate, resident and other services, and others. The rest of the economic sectors are assigned to *X* (with some barriers to entry in the domestic market): manufacturing, utilities, construction, transport, and banking.

In richer countries, *A* should be larger than agriculture, as services constitute a major part of GDP. In the U.S., *A* consists of agriculture, leisure and hospitality (which includes food service and drinking places, arts, entertainment and recreation, for example) and other services (mostly small scale services, such as repair and maintenance, personal care services like barber shops, beauty and nail salons, dry cleaning and laundry, for instance).

The calibrated parameter values under both arrangements are reported in Table 1. There are 12 model parameters in total but 3 of them do not enter into steady-state analysis, namely θ, β and σ. The values of industrial sector technology parameters π_0, π_1 and π_2 matter not in absolute, but in relative terms; and so, without loss of generality, set $\pi_0 = 1$. To reflect the assumption that, if used efficiently, the next technological innovation can be around three times more productive than the currently operating technology, $\pi_1 = 3.0$ and $\pi_2 = 9.0$.[23]

The remaining six parameters, $\alpha, \phi, \eta, \mu, \rho$ and ψ, are calibrated so that the equilibrium outcomes under the two arrangements match stylized facts (1)-(4) as observed in the Chinese and U.S. economies below.

Stylized Fact 1: Sector *A*'s fraction of total employment is 0.61 in the monopoly rights country, and 0.14 in the free enterprise country.[24]

Stylized Fact 2: Land rental income relative to the sum of land rental income and sector *A*'s wage income is 0.14 in both economies.[25]

Stylized Fact 3: The intermediate goods' share of total Sector *A*'s product is 0.10 in the "monopoly rights" economy and 0.72 in the "free enterprise" economy.[26]

Stylized Fact 4: The economic rents received by workers in the differentiated goods sector *X* are 150 percent of sector *A*'s wage in the "monopoly rights" economy, implying $w_x / w_a = 1.5$.

That is, $N_a = 0.73$ under "monopoly rights" (MR) and 0.14 under "free enterprise" (FE); $rL_a / (rL_a + w_a N_a) = 0.14$ under both arrangements; $pX_a / A = 0.10$ under "MR" and 0.72 under "FE"; and finally, $w_x / w_a = 1.5$ under "MR".

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23 The thrust of the conclusion does not change if $\pi_1 = 2.5$ and $\pi_2 = 6.25$, for example.

24 Based on the China's employment data from 2003-08 and U.S. employment data during 2002-10.

25 For China, I impute land rental value in sector *A* by assuming it to be 0.05 percent of estimated total agricultural land value. For the U.S., I take the value from Parente and Prescott (1999).

26 The share of intermediate goods, as defined in the model, in total sector A product is difficult to estimate. Intermediate goods in the model are those directly used in the production process, such as fertilizers, depreciation of tractors, machines, etc. Parente and Prescott (1999) estimates this figure for India to be roughly 0.02. I take the figure for China to be higher, and closer to 0.1. The finding is relatively robust to changes in these numbers. The intermediate goods' share of total sector *A*'s product is estimated to be 0.72 in the United States.

Table 1
Calibrated parameter values

Preference Parameters	"X" Sector Technology Parameters	"A" Sector Technology Parameters
$\eta = -0.01$ $\mu = 1.61$	$\pi_0 = 1.00$ $\pi_1 = 3.00$ $\pi_2 = 9.00$ $\phi = 0.14$	$\alpha = 0.86$ $\rho = 0.61$ $\psi = 0.30$

Computation of "Monopoly Rights" Equilibrium

Model's GDP can be computed from three sources: (1) GDP as total value added, i.e. $Y = \sum_{A,X}(\text{Value Added}) = (A - pX_a) + pX$; (2) GDP as the sum of final products, i.e. $Y = A + p(X - X_a)$; and, (3) GDP as total income generated in the economy, i.e. $Y = \sum_{A,X}(\text{Income}) = (w_a N_a + rL_a) + w_X N_X$. Note that GDP reported in Tables 2-3 is not only an aggregate figure, but is also *per capita* since the measure of population, N, is 1.

The results are summarized in Tables 2 and 3: Under "free enterprise," agricultural and small services firms use much fewer labor inputs, but much more differentiated intermediate goods relative to total output. Under "monopoly rights," agricultural (or equivalently, the no-barrier-to-entry and labor-intensive) households are poorer than industrial households and consume less on a per capita basis.

Wages tend to equalize across sectors under "free enterprise," because there is no economic rent to be derived and protected. Prices are also different across arrangements. "Industrial" goods that are produced by protected firms are more expensive (in terms of the no barrier to entry, "agricultural" goods) under "monopoly rights" than under "free enterprise." As a result, sector A uses less of the intermediate goods and services in the "monopoly rights" economy. In a "free enterprise" economy, "agricultural" households face more or less similar budget constraint as that of "industrial" households. They consume roughly equal amount. In addition, the "agricultural" households will get to consume relatively more of the X goods and services in the "free enterprise" economy (because relative price of X goods is now much lower).

Note that the *allocations* in Table 2 are not to be compared directly across arrangements or economies because the two economies have different relative prices. To allow for direct comparison, a common set of "international prices" is calculated and used to compute real GDP at purchasing power parity (PPP) and compare their values. International prices and PPP are calculated based on the Geary-Khamis approach; the same way the Summers and Heston's Penn World Table calculates GDP at PPP (see Appendix for further details).

Table 2
Equilibrium Prices and Allocations under Two Economic Arrangements

Monopoly Rights Economy, $\left(x^M\right)$	**Free Enterprise Economy, $\left(\hat{x}\right)$**
Price System:	Price System:
$p = 0.55$	$p = 0.18$
$w_a = 0.55$	$w_a = 1.57$
$w_x = 0.83$	$w_x = 1.57$
$r = 0.055$	$r = 0.035$
Household Allocations:	Household Allocations:
$a_a = 0.38$	$a_a = 0.99$
$x_a = 0.42$	$x_a = 3.50$
$a_x = 0.55$	$a_x = 0.99$
$x_x = 0.61$	$x_x = 3.50$
Aggregate Inputs and Products:	Aggregate Inputs and Products:
$X_a = 0.09$	$X_a = 4.42$
$N_a = 0.61$	$N_a = 0.14$
$L_a = 1.00$	$L_a = 1.00$
$N_x = 0.39$	$N_x = 0.86$
$A = 0.44$	$A = 1.00$
$X = 0.59$	$X = 7.74$
$Y = 0.72$	$Y = 1.57$

The long-run results reported in Table 3 appear to be quantitatively sensible. For example, the model's value of A/Y matches quite well with the data (0.62 versus 0.55). The "industrial" sector, *X*, generates a lion's share of the total value added and wage income under "free enterprise;" on the other hand, sector *A*'s shares of the total value added and wage income shrink by as much as four times. Furthermore, the unit price of the industrial goods relative to the *A* goods is about 3¼ times higher in the poor country with "monopoly rights" than in the rich country with "free enterprise." This is roughly the ratio of the prices of investment goods to consumption goods across rich and poor countries in the Summers and Heston data (3-4 times).

In the long run, the effect on output from eliminating monopoly rights is substantial. Model's GDP in PPP terms increases by as much as 3½ times in steady state. Since there is no capital in the model, and labor and land services are assumed to be similar across arrangements, this number is equivalent to the difference in TFP between the two arrangements. Without TFP difference of this magnitude (and assuming fixed aggregate capital and human capital stock for the sake of comparison), Chinese output per worker under "monopoly rights" would be around 45 percent of its output per worker under "free enterprise," which is close to the number (50 percent of U.S. output per worker) calculated by Hall and Jones (1999).[27] Inefficient operation of inferior technology in a large swath of industry and services accounts for lower aggregate TFP in China vis-a-vis the U.S., *which in the model stands for China under "free enterprise,"* over time. In this calibration, sector X uses only about half of its potential productivity level.

Table 3

Comparison of Quantitative Performances under the Two Arrangements

	Monopoly Rights Arrangement	Free Enterprise Arrangement
Relative GDP at PPP (with "MR" as numeraire economy)	1.00	3.58
Shares of Final Product		
Industrial Goods and Services, $p(X - X_a)/Y$	0.38	0.37
Agricultural Goods/Selected Services, A/Y	0.62	0.63
Shares of National Income		
Land Rent Income, rL/Y	0.08	0.02
"Industrial" Wage Income, $w_x N_x / Y$	0.45	0.84
"Agricultural" Wage Income, $w_a N_a / Y$	0.47	0.14
Shares of Valued Added		
Industrial Sector, pX/Y	0.45	0.86
Agricultural Sector, $(A - pX_a)/Y$	0.55	0.14
Relative Wages		
w_x / w_a	1.50	1.00
"Industrial" Sector Productivity[28]		
π_x	1.50	9.00
Relative Output Prices		
$p = p_x / p_a$	0.55	0.17

[27] This calculation uses capital shares of 0.5 and 0.36 for China and the U.S., respectively.

[28] Or "average product of labor" in sector *X*.

In a richer model with capital accumulation, however, the effect on output from increases in TFP would be amplified because capital would accumulate endogenously in response to increasing TFP to keep the long-run rate of return constant. The difference in GDP per capita (at PPP) between the two arrangements would then be equal to the factor difference in TFP (here, 3½) raised to the power of 1/(1- reproducible capital share). Given China's reproducible capital share at approximately 0.45, the adjusted difference in GDP per capita at PPP would be approximately 10 times, roughly similar to the measured difference between U.S. and China's output per capita and output per worker at PPP between 2000-09 (8.5 and 10 times, respectively).

V. Conclusion

A large number of research papers has stressed that misallocation of resources across firms can adversely affect aggregate TFP in an economy. This paper uses an abstract model that incorporates strategic behavior of vested interest groups to block adoption of better work practice to measure potential gains from eliminating protected monopoly rights in the case of China. Confronted with entering firms—domestic or foreign—armed with better technology, rational vested interest groups that are not protected will have no choice but to set their own work practices at the best standard available to compete. The same outcome would materialize whenever entry threat prospects are credible.

The numerical results in this paper require a few caveats. The simple abstract model used could be an inaccurate approximation of China and the United States. There could well be large measurement error in the data as well as lack of data, which lead to inaccuracies in the calibration exercise. Therefore, this calculation is very much a first pass. Nevertheless, the results underscore the strategic importance of competition in improving total factor productivity and competitiveness.

The long-run results reported here appear to be quantitatively sensible based on comparison with long-term experience in the United States. The large gaps in TFP and GDP per capita between China and the U.S. today could be narrowed significantly if China transforms its inefficient "monopoly rights" arrangement in the domestic market (especially in service sectors) into one that minimizes vested interest groups' ability and incentive to deter better technology and work practices. Should China de-monopolize its domestic market, Chinese GDP per capita could be 10 times higher than otherwise in the long run. More important, most of that increase will have originated from TFP gains. And the room for reallocation gains should come mainly from the service sectors.

As China continues with reform, it can apply the same fundamental insights that make manufacturing *exports* a phenomenal success to achieve world-class services and agricultural sector TFP. The reform efforts should therefore focus on productivity improvement in the financial services, construction (which is by far the most labor intensive), transport, education, health, telecoms, and utilities. By persisting with reform to weaken protection and encourage entry, competitive pressure will help transform work practice across Chinese firms.

With these reform efforts, business strategies based on creating and sustaining privileged access will be increasingly outdated. More services will be produced at more affordable prices. Wages will rise and converge across sectors. Over time, physical capital accumulation, as well as education and skill acquisition will necessarily follow to normalize the rates of return, which will have risen from higher TFP. More and more Chinese firms will innovate and export best practice to the world. Chinese workers and households will be made considerably better off than otherwise as the deadweight is removed. And large international income gap between China and today's leading industrialized countries will be eliminated.

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APPENDIX

GDP at Purchasing Power Parity Prices (The Geary-Khamis approach)

In this section, I demonstrate how GDP at PPP in the computation experiment is obtained. More details can be found in Kravis et al (1982).

Let $\overline{\Pi}_i$ and $\overline{\Gamma}_j$ denote the international price of category i of goods, and purchasing power parity of economy j, respectively. Then, in the context of our model economy, let $i \in \{A, X\}$ and $j \in \{M, F\}$, where M and F stand for "monopoly rights" and "free enterprise" economies, respectively. Let the M economy be our numeraire economy, i.e. $\text{PPP}_{ij} = p_{ij} / p_{i,M}$ and $Q_{ij} = \dfrac{p_{ij} \cdot q_{ij}}{p_{ij} / p_{i,M}} = p_{i,M} \cdot q_{ij}$.

Then, define

$$\overline{\Pi}_i = \sum_{j=M,F} \frac{\text{PPP}_{ij}}{\overline{\Gamma}_j} \cdot \frac{Q_{ij}}{\sum_{j=M,F} Q_{ij}}, \qquad i = A, X \tag{*}$$

$$\overline{\Gamma}_j = \frac{\sum_{i=A,X} \text{PPP}_{ij} \cdot Q_{ij}}{\sum_{i=A,X} \overline{\Pi}_i \cdot Q_{ij}}, \qquad j = M, F \tag{**}$$

Equations (*) and (**) carry a clear economic interpretation: (*) states that the international price of category i goods is the quantity-weighted average of the purchasing-power-adjusted prices of category i goods in both economies, M and F. (**) states that the purchasing power of an economy's currency is equal to the ratio of its total costs of goods at that economy's prices to the cost at international prices.

In our computation exercises, $PPP_{A,M} = \dfrac{p_{A,M}}{p_{A,M}} = 1$, $PPP_{X,M} = \dfrac{p_{X,M}}{p_{X,M}} = 1$, $PPP_{A,F} = \dfrac{p_{A,F}}{p_{A,M}} = \dfrac{1}{1} = 1$, and $PPP_{X,F} = \dfrac{p_{X,F}}{p_{X,M}} = \dfrac{\hat{p}}{p^M}$. Therefore, (*) and (**) can be rewritten as follows:

$$\overline{\Pi}_A = \frac{1}{PPP_M} \cdot \frac{A^M}{\left(A^M + \hat{A}\right)} + \frac{1}{PPP_F} \cdot \frac{\hat{A}}{\left(A^M + \hat{A}\right)} \tag{A1}$$

$$\overline{\Pi}_X = \frac{1}{PPP_M} \cdot \frac{X^M}{\left(X^M + \hat{X}\right)} + \frac{\hat{p}/p^M}{PPP_F} \cdot \frac{\hat{X}}{\left(X^M + \hat{X}\right)} \tag{A2}$$

$$\overline{\Gamma}_M = PPP_M = \frac{A^M + X^M}{\overline{\Pi}_A A^M + \overline{\Pi}_X X^M} \tag{A3}$$

$$\overline{\Gamma}_F = PPP_F = \frac{\hat{A} + \left(\frac{\hat{p}}{p^M} \cdot \hat{X} \right)}{\overline{\Pi}_A \hat{A} + \overline{\Pi}_X \hat{X}} \tag{A4}$$

Substituting all the known equilibrium prices and allocations solved earlier, and solve (A1)-(A4) simultaneously.