Japan's Economic Puzzle

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Abstract:

This paper examines Japan's economic performance in recent years, uncovering a narrative that challenges conventional views. Despite slow productivity growth, Japan maintains the highest economic complexity globally due to its sophisticated export portfolio. The study reveals that while Japan has been experiencing a decline in goods export market shares it has had a rise in services exports, particularly in R&D licensing. Furthermore, Japan has significantly increased its net foreign assets and direct investments abroad, resulting in abnormal high returns. These results put together suggest that Japanese firms —perhaps in reaction to a stagnant domestic labor force—are leveraging their extensive knowledge capital by investing and redeploying resources internationally, which are generating these higher returns. The increasing wealth generated abroad results, we show, in an expansion of non-tradable activities which are less productive, driving down aggregate productivity growth. The paper also highlights concerns over declining innovation quality, posing risks to Japan's future economic performance and its ability to redeploy its accumulated knowledge to enjoy from unusually high returns from their foreign investments. The findings emphasize the need for policy reforms to enhance innovation quality to sustain Japan's productivity of non-tradable activities and with an immigration policy that may change the downward trend in labor supply.

About the Growth Lab

The Growth Lab's multidisciplinary team, led by Professor Ricardo Hausmann, pushes the frontiers of research on economic growth and development policy. The Growth Lab advances academic research on the nature of economic growth and conducts applied, place-based engagements that aim to understand context-specific growth processes, address key constraints, and identify promising opportunities. Key frameworks developed at the Growth Lab include Growth Diagnostics and Economic Complexity. Growth Diagnostics is a systematic methodology that aims to identify the most binding constraints to better growth outcomes, allowing policymakers to take the most impactful actions. Economic Complexity is a growing field of research that sees the economy as composed of distributed knowledge and productive capabilities that must be networked in order to be used in production and sees growth as the expansion of both the underlying knowledge and its uses. Through its research and teaching activities, the Growth Lab has become a global thought leader offering breakthrough ideas, methods, and tools that help policymakers, stakeholders and scholars find ways to accelerate economic growth and expand opportunity across the world.

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1. Introduction

Japan's economic landscape often evokes a sense of paradox. When viewed through the conventional metrics of GDP and productivity growth, it appears as though Japan lags its counterparts like the United States and Germany. Yet, this perspective fails to capture the full spectrum of Japan's economic prowess. By applying the lens of economic complexity, a different and more dynamic narrative emerges.

Japan boasts the most complex economy in the world, a distinction it has held since 1981, according to the Economic Complexity Index. This indicator reflects Japan's unrivaled sophistication in producing and exporting a diverse array of highly advanced products. At the same time, however, Japan faces significant and well-known structural challenges, including an aging population, a stagnated labor force, and consequently, a rapidly increasing age dependency ratio.

The domestic challenges are so large that might jeopardize Japan's ability to remain the most complex of the world, which in turn can hinder further productivity growth. This paper examines the dynamics that the Japanese economy faces in the presence of this dichotomy (high complexity but enormous domestic challenges) and explores the evolving Japan's global economic footprint over the past few decades to better understand the state of its overall economy.

Our main findings put together suggests that in response to the enormous domestic challenges in the economy, Japanese firms have sought to offset these constraints by expanding their operations internationally through foreign investments. By investing in foreign markets, Japanese firms can access larger and more diverse labor pools, enabling them to continue growing despite domestic labor shortages. These Japanese investments abroad, accompanied by the unique accumulated knowledge of the Japanese economy (i.e., technology, best practices, and more), has resulted in very high returns to these investments. The subsequent increase in wealth to the economy has inevitably resulted in a domestic expansion into non-tradable, less productive, sectors of the economy which lowers aggregate productivity growth. Overall, we argue, the sluggish productivity growth in Japan is a result of these dynamics.

To get to this conclusion we start our investigation by first examining the dynamics of Japanese exports over the past decades. We find that Japan has continued to specialize in highly sophisticated products, which explains its leadership in the economic complexity rankings. However, we also find that Japanese goods have lost export market shares across the board: its market share in goods dropped from about 11.2% in 1986 to 3.9% in 2021. This decline is more pronounced than that seen in other advanced industrialized nations such as the United States and Germany, where the fall in global market share was 2.8 and 5.4 percentage points, respectively, even though they started from a higher base.

In contrast to trade in goods, Japan has a more favorable performance in the export of services. We highlight Japan's intellectual property (IP) exports as their most prominent category within services in terms of size and global market share. We evaluate Japanese exports of IP to the USA – for which we have highly disaggregated data – and find that over 90 percent of it consists of R&D licensing. This subcategory is more knowledge-intensive than others within IP, such as broadcasting, TV or book rights. Japan also has the largest market share in the world for R&D licensing to the USA.

When it comes to the investments by Japan abroad, the picture is even brighter: Japan has significantly increased its net foreign asset positions, particularly after the turn of the century. In fact, between 1996 and 2022, Japan nearly quadrupled the value of its assets abroad from USD 2.7 trillion to USD 10.3 trillion. An important driver of this growth is reflected in Japan's stock of outward direct investment, which increased by a factor of almost 8 from USD 263 billion to USD 2.1 trillion during the same period.

Moreover, the returns to those direct investments have grown significantly, too, with abnormal returns consistently much larger than for any other investment positions. The data shows that dividends stemming from direct investment abroad account for 55% of the gross primary income of Japan's current account, having grown by a factor of almost 15 from USD 14 billion in 1996 to USD 206 billion in 2022.

The success of Japan's investments abroad is consistent with our estimates of a growing stock of "dark matter" assets (Hausmann & Sturzenegger, 2007). These dark matter assets are a measure of Japan's "knowledge-capital", which accounts for the significant excess returns generated by its direct investments abroad. When accounting for the 'dark matter' of Japanese investments abroad by capitalizing the flows of income these investments generate at the average global return on investment, we find that the value of FDI assets doubles in size from the USD 2.1 trillion in book value to USD 4.2 trillion in economic value.

The revenue generated from investments abroad reflects itself in Japan's Gross National Income, which exceeds the income generated inside Japan – as measured by its Gross Domestic Product (GDP) – by an unusually large 6 percent in 2022.

The global footprint of the Japanese economy has expanded significantly over the past decade. Therefore, measuring Japan's economic performance without carefully examining these dynamics misses an important part of the full picture. This is reflected in productivity dynamics: our analysis finds that the productivity growth experienced by Japan over the past decades as compared to other industrialized nations, albeit slow, is entirely driven by firms with activities abroad, for which aggregate productivity grew by more than 10 percent between 2012 to 2019. Clearly, these measures of productivity do not take into account the increases in productivity of Japanese subsidiaries abroad. We also find that productivity of purely domestic firms has been lackluster, bringing down the average for the aggregate economy.

Moreover, the highly internationalized industries (i.e. industries with a large presence of subsidiaries abroad) tend to be in tradable activities such as IT, manufacturing and mining. And these sectors have been shrinking in terms of their relative use of Japanese labor services. It is the low-internationalization, non-tradable industries that have been increasing their weight in terms Japanese labor services. Hence, high / rising productivity industries shrink their labor share, lowering the overall productivity growth. This process may be more important in Japan than in Germany or the US because of Japan's stagnant labor supply.

Our investigation suggests that the good performance of Japanese economic activities abroad was based on its numerous innovations across several technology classes (Bahar and Strauss, 2018). However, we also document a declining trend in the quality of Japanese innovations, calling into question the sustainability of the current superior performance of the Japanese economy abroad. For Japan to remain competitive it must find ways to reverse this decline in innovation quality. Failing to put forward policy reforms that can achieve high-quality innovation poses potential challenges to Japan's future global economic performance.

This study concludes that Japan's economic narrative is more vibrant and successful than commonly perceived. While its labor force is stagnant and will likely decline, its knowledge capital is being increasingly deployed abroad, creating economic dynamism elsewhere and generating returns for Japan from activities beyond its borders.

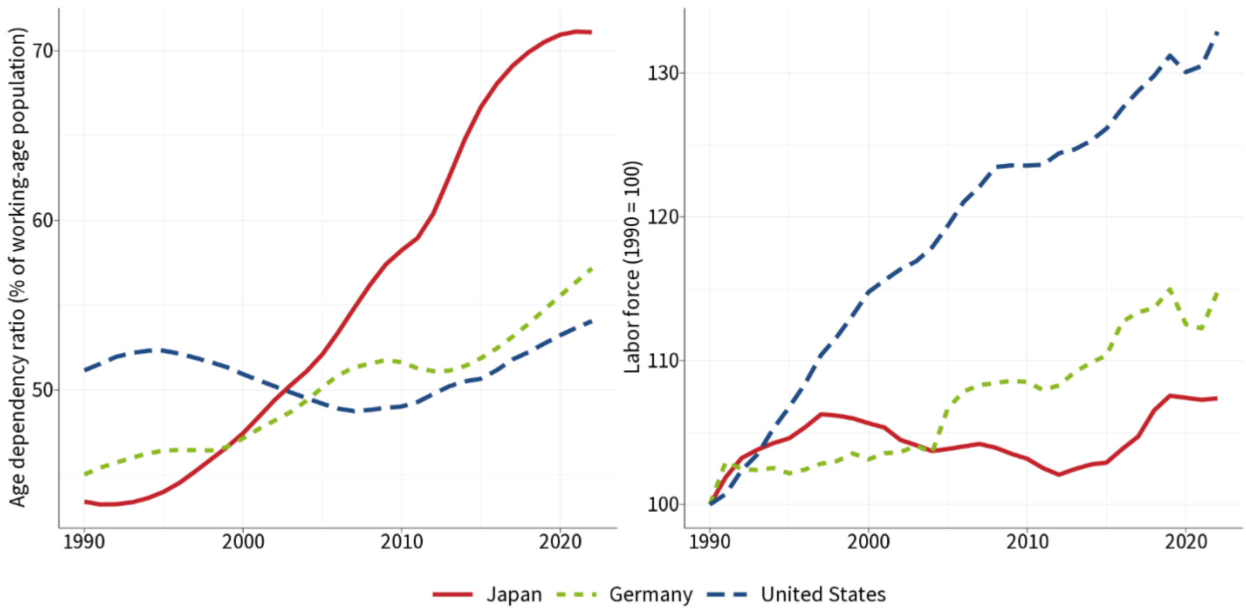
2. Japan's Economy: A Puzzle

Japan's current socio-economic landscape is characterized by a trio of intertwined challenges that are of significant concern. Japan's stagnant labor force [1] (see right panel of Figure 1) will limit the overall rate of growth of the economy. Given rising age-dependency ratios (see left panel of Figure 1) and declining overall population, the labor force is likely to decline in the coming years, a pattern that was already

[1] Our characterization of Japan's stagnated labor force comes from the fact that, as seen in the figure, there is a sharp drop in the size of the labor force between the late 1990s and the early 2010s, followed by a significant rise. According to the literature, this rise responds to the rise of female labor participation in the overall labor force. Overall, when considering this compositional aspect of the labor force, the recent trend of growth is limited, and it is likely that the labor force will continue to shrink, or at best, stagnate (Shambaugh et al., 2017).

observed in the decade following the mid-1990s. These trends are increasing the share of national income that is allocated to healthcare and pensions, limiting the dynamism of the economy.

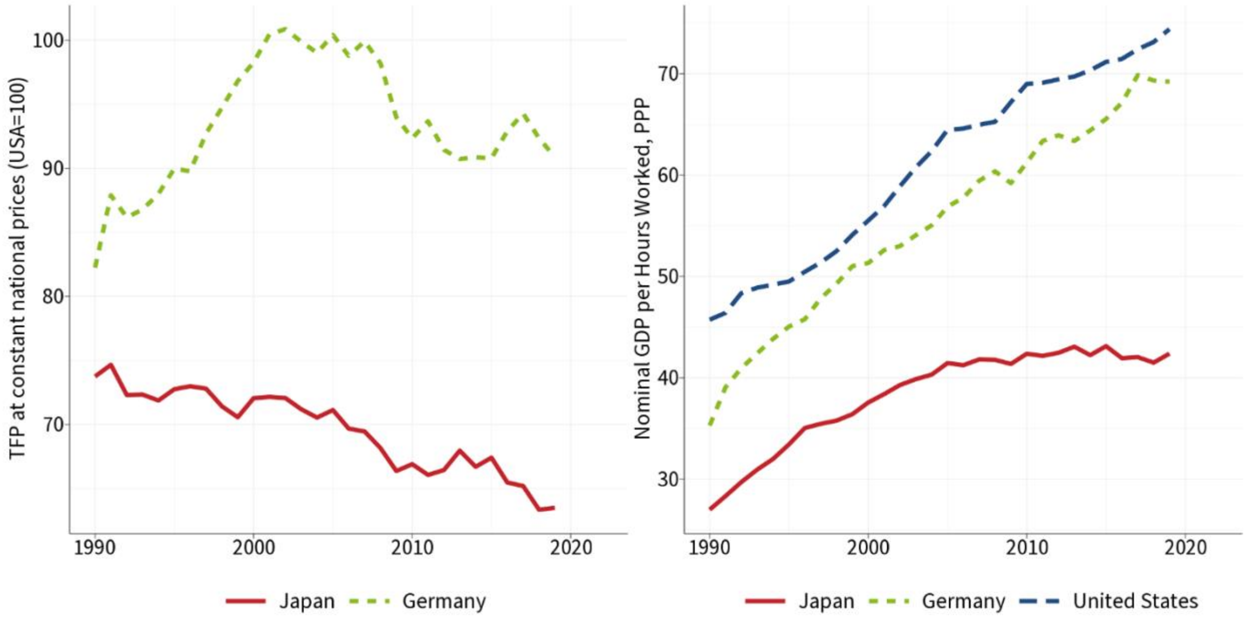
Figure 1. Age-Dependency Ratio and Labor Force (1990-2022)



Note: The left panel shows the evolution of the Age-Dependency Ratio which expresses the ratio between different age groups (0-15 and 65-plus as a share of population aged 16-64). The right panel is an index of the Labor Force that shows its evolution and growth in Japan and peers. Source: World Development Indicators, 2023.

Given that these trends are more acute in Japan than in other economies such as the United States and Germany, they show up in a noticeable slowdown in the country's economic growth rate. But the slowdown in GDP growth goes beyond the impact of the labor force numbers: there has also been a marked lag in the productivity per worker relative to other Western countries such as the United States and Germany (See Figure 2), at least as conventionally measured.

Figure 2. TFP and GDP per Hour Worked: Japan and Peers



Note: The left panel shows the evolution of Total Factor Productivity in comparison to US levels for Germany and Japan. The right panel shows the evolution of GDP per hour worked in Japan and peers. Source: Penn World Tables 10.01 and authors' calculations.

Contrasting with this lackluster performance, the country has a remarkable level of economic complexity. According to the Atlas of Economic Complexity, Japan ranks first in the world in terms of its economic complexity, a position it has maintained since 1981. This reflects the country's advanced technological capabilities and sophisticated manufacturing products.

High complexity and sluggish economic growth, although seemingly contradictory, can coexist (see Appendix B). High economic complexity suggests that a very large fraction of global technology has already been adopted. This fact coupled with a low Complexity Outlook Index suggests that there are very few opportunities for growth based on the adoption of technologies that already exist somewhere in the world. Instead, this suggests that, to keep progressing, Japan must innovate at the technological frontier.

In the context of a stagnant labor force, the Japanese economy has been moving out of the least complex industries and has concentrated in the most complex ones (see Appendix B2 and Table B1). This makes us pose the following hypothesis: Japanese firms have been redeploying their productive knowledge abroad –alongside with investment— to be able to put into operation and extract more value than can be achieved with the limited human resources at home. This approach would not only alleviate some of the domestic pressures caused by demographic challenges but also open new avenues to monetize its intellectual capital through economic activities abroad. By extending its reach beyond its borders, Japan can capitalize on its strengths, fostering partnerships and creating value in other economies. To assess whether this is indeed happening, we start by carefully looking at Japan's economic interactions with the rest of the world.

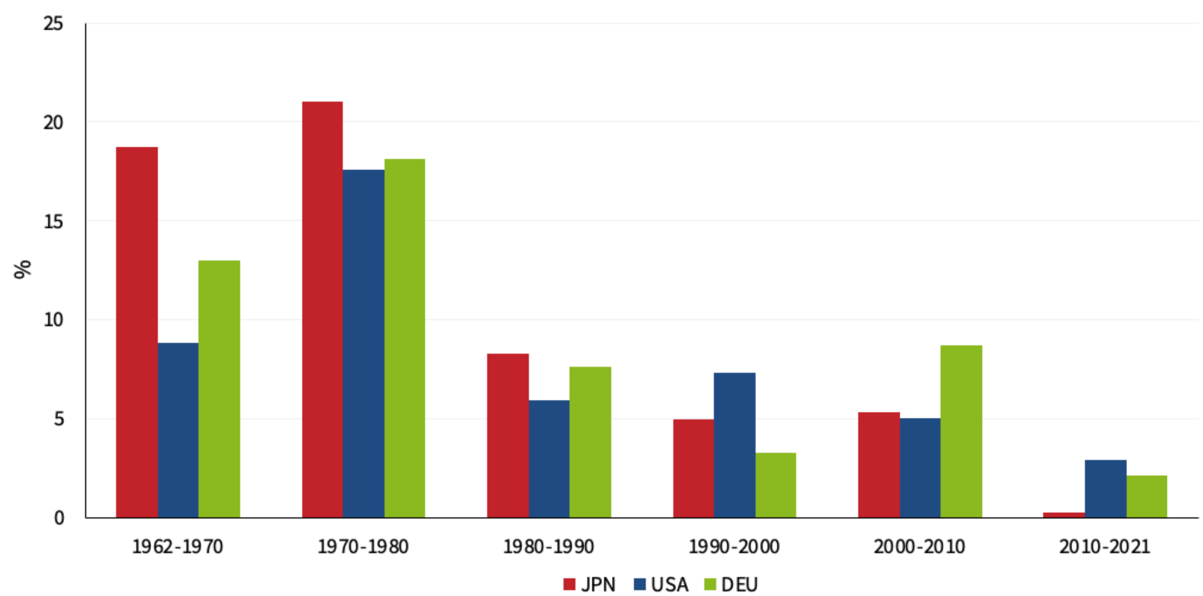
In the next section, we delve deeper into Japan's economic footprint abroad, looking into exports of goods and services, as well as foreign direct investment.

3. A Deeper Dive into Japan's Global Economic Footprint

Exports of Goods and Services

The growth of a country's exports of goods and services is a good indication of its overall dynamism and its competitiveness. In this respect, Japan had a remarkably fast growth rate of exports between 1960 and 1990, with rates that exceeded those of the US and Germany. However, since the Global Financial Crisis, exports have been stagnant and have underperformed those of the other two countries (see Figure 3). In terms of exports per worker, they even shrank at an annualized rate of -0.32% from 2010 to 2021. Although export growth also slowed in Germany and the United States compared to previous decades, they still grew by more than 2% a year, on average.

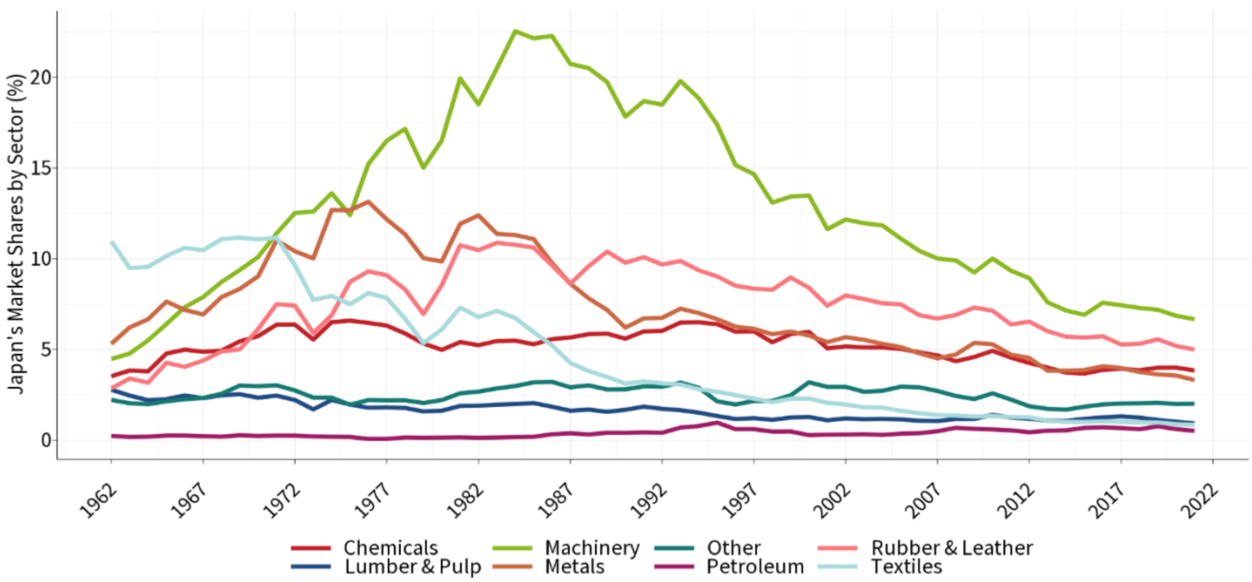
Figure 3. Exports Growth Rates by Decade (1962-2021)



Note: The graph shows the CAGR of goods exports in each decade for Japan, the United States, and Germany. Source: The Atlas of Economic Complexity and authors' calculations.

Consequently, Japan's global market share in goods exports also declined steadily over the past 4 decades, reflecting an important loss in global competitiveness. In 1986, Japan's market share was 11.2% of global exports. For export industries in that same year, Japan's market share was 22.3%% of machinery, 9.8% of metals, and 9.6% of rubber & leather. By 2021, the global export market shares shrunk to 3.9%; and the export market shares for those same industries declined to 6.7% for machinery, 3.3% for metals and 4.9% for rubber & leather. This decline is reflected across all industries in Figure 4 (except for a negligible increase in petroleum derivatives).

Figure 4. Market Share of Goods Exports by Category (1962-2021)



Note: The figure plots market shares of Japan's exports to the rest of the world in different categories. Source: The Atlas of Economic Complexity and authors' calculations.

Japan's loss in market shares has not affected its standing as the most complex economy in the world[2]. This is because Japan's export basket has continued to concentrate on fewer goods that are relatively more complex (See Figure B2). As compared to the USA and Germany, Japan's export basket is more concentrated, but it has become increasingly more focused on complex goods as the less complex products have seen more rapid declines. Appendix A defines the main concepts of economic complexity, and in Appendix B we go further in explaining these dynamics in more detail.

Yet, overall, the loss of competitiveness of Japanese exporters of goods, as expressed in their dwindling market shares, is consistent with our premise: with a stagnant labor force, Japan has concentrated more of its human talent in more complex industries while it has been abandoning the less sophisticated ones.

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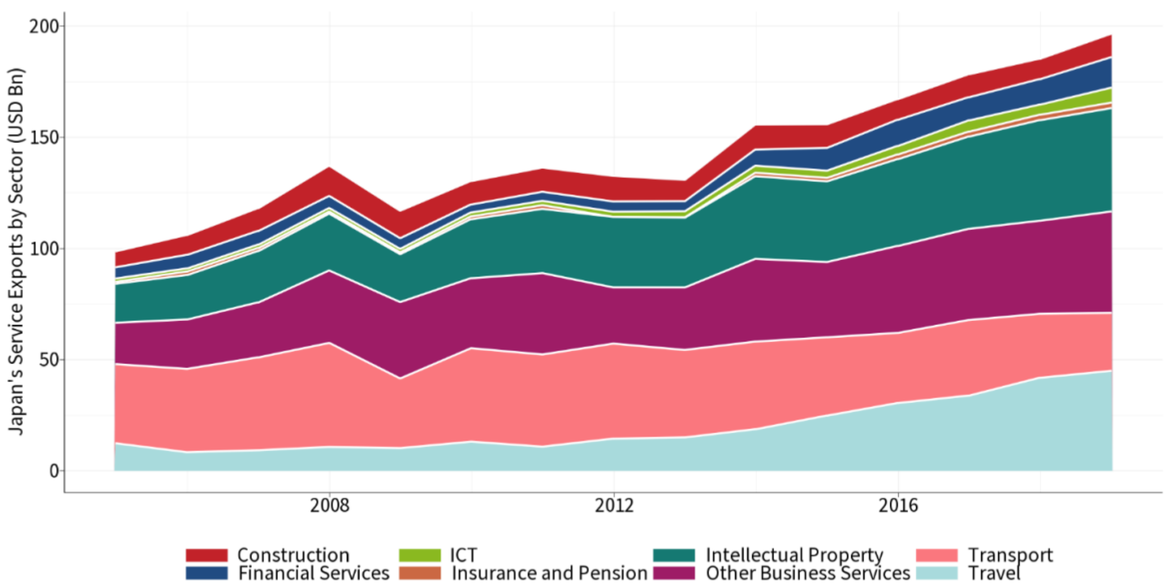
[2] The Economic Complexity Index uses only data goods. This is because goods statistics are highly disaggregated in international trade statistics into some 1,000 products, while services statistics are very aggregated into less than 10 categories.

Therefore, Japanese firms may find it more advantageous to move production abroad, leveraging their knowledge, technology and managerial capacity while using human and other resources from elsewhere[3].

To explore the performance of Japanese service exports, we leverage data from the World Trade Organization (WTO) and the OECD to analyze 12 categories of services from 2005 to 2019 (Liberatore & Wettstein, 2021).

In contrast to goods exports, services grew steadily from USD 102 billion in 2005 to 204 billion in 2019. Notably, intellectual property (IP) became the largest category within services, growing 171% within the same period, and standing at USD 46 billion in 2019. Consequently, an important takeaway is that the exports of *codified knowledge* has become a major source of revenue for Japan. The growth and evolution of Japan's service exports can be seen in Figure 5.

Figure 5. Services Exports by Sector (2005-2019)



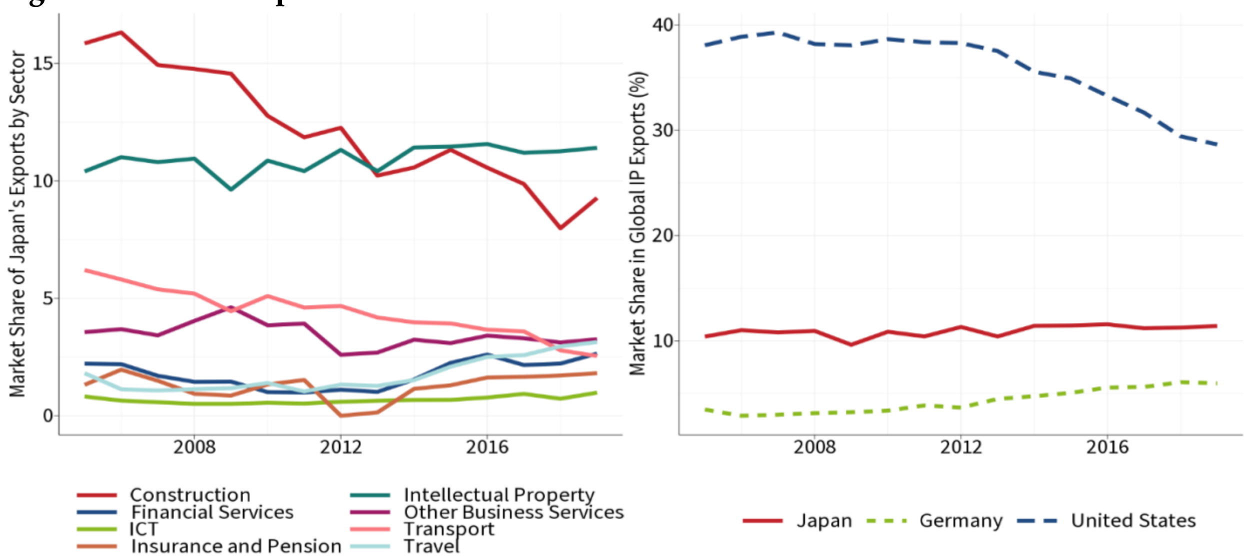
Note: This graph shows the services trade volumes of different sectors exported by Japan by category. Source: World Trade Organization (WTO), 2023.

Besides its growth in nominal value, Japan has been able to sustain a high market share in IP exports. IP is also the service category in which Japan holds its highest global market share. It is currently the third

[3] This explanation is compatible with the Helpman, Melitz and Yeaple (2004) model in which the more productive firms in an industry substitute exports for so-called horizontal FDI (i.e. FDI that sells the same product but from a subsidiary abroad), but with a more intense impact on lower complexity products. In short, lower complexity industries move out first and faster.

largest exporter of IP, behind the United States (USD 116.7 billion) and the Netherlands (USD 66.4 billion). In contrast to the decline of market shares in goods and other services such as construction and transport, the Japanese share in IP rose from 10.4% in 2005 to 11.4% in 2019 (see Figure **6**). A stable market share in this context could be construed as a sign of resilience, not stagnation. Given the entrance of new global players in this period, this is a good performance. From 2010 to 2019, global IP trade grew 66.8%, meaning that Japan's exports grew even faster, and the United States lost 10 percentage points in its market share.

Figure 6. Services Exports' Market Share

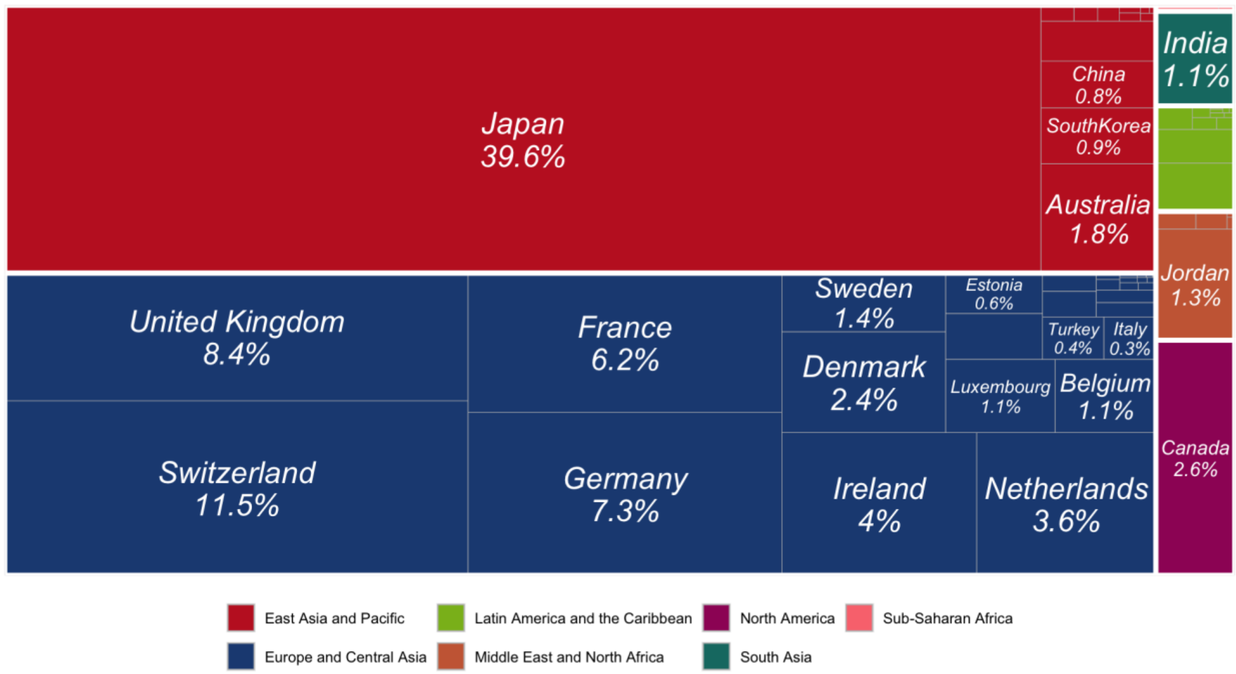


Note: The left panel shows the market shares of Japanese export of services to the rest of the world by category. The right panel shows the market shares of IP exports by Japan, Germany, and the United States, each to the rest of the world. Source: World Trade Organization (WTO), 2023; authors' calculations.

To dig deeper into IP service exports, we rely on detailed data on US imports of services divided into 61 categories, published by the United States Bureau of Economic Analysis (BEA). The dataset divides IP exports into 7 subcategories. From the perspective of the USA, its largest IP import category is R&D licensing (54%), followed by software licensing (27%), and trademarks (12%). These are followed by live events broadcasting and recording, books and sound recording, movies and TV programming, and franchise fees (combined 7%). The Japanese IP exports basket to the USA is heavily concentrated in R&D licensing (91%) and software licensing (6%) which are the most knowledge-intensive subcategories.

We also find that, at 38%, Japan has the largest market share for R&D licensing to the USA of any country in the world (see Figure 7). Some of the other countries with high market share such as Estonia, Ireland and the Netherlands, are low tax jurisdictions where global companies tend to register their IP revenues. This indicates that Japan's R&D investments are highly competitive globally. Unfortunately, we do not have equivalent data for other countries, but we know, from Japanese sources, that IP exports to the US represent only 20% of Japan's global exports of IP. This evidence is suggestive of the predominance of Japan in the R&D licensing market, and the quality and value of Japan's IP exports.

Figure 7. R&D Licensing Exports to the United States by country of origin (2013-2022).



Note: The figure shows the market share of different countries in the basket of IP imports of the US. Source: Bureau of Economic Analysis (BEA) and authors' calculations.

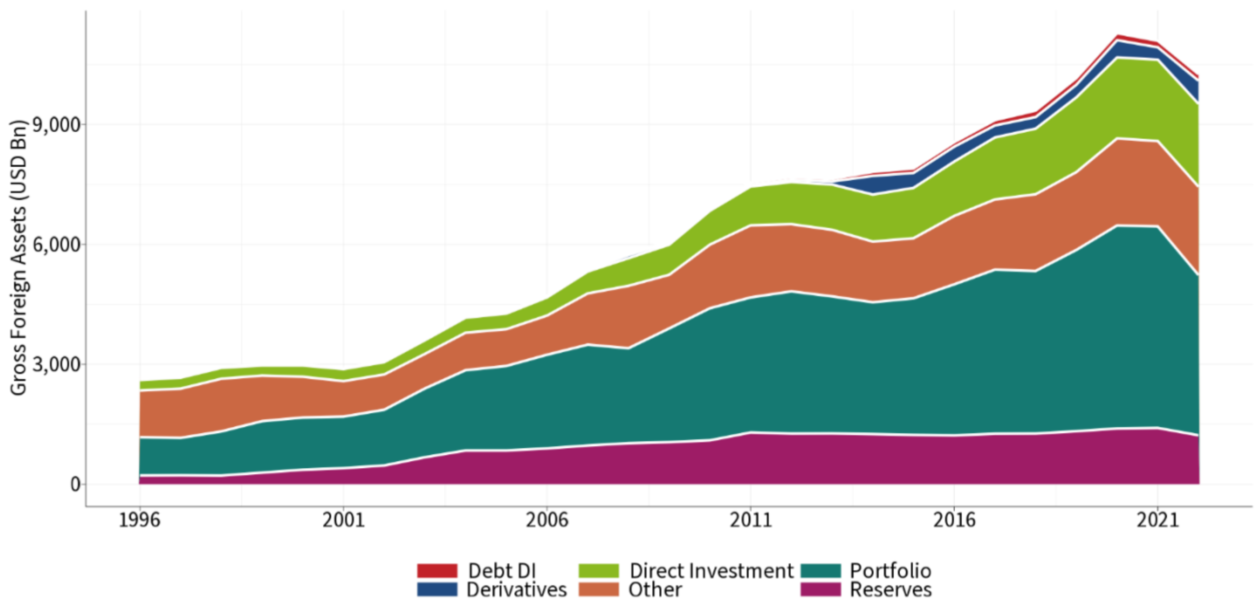
Overall, the continuous rise in IP exports signals a growing appetite for Japanese knowledge in international markets. This is consistent with the idea that Japan is very knowledge intensive and that it is monetizing this asset by deploying it abroad.

Foreign Investments

In this section, we explore another important aspect of Japan's global footprint: Investments in the rest of the world.

Between 1996 and 2022, Japan nearly quadrupled the value of its assets abroad from USD 2.7 trillion to USD 10.3 trillion, as shown in Figure 8. Looking at the decomposition of those assets, we note that an important proportion of them correspond to portfolio investments, which increased by a factor of 4.2 during the same period, likely reflecting investments by pension funds, insurance companies and other non-controlling interests outside of Japan. However, the most dynamic component is outward direct investment, reflecting ownership of economic activity abroad, which increased by a factor of almost 8 during the same period, from USD 263 billion to USD 2.1 trillion.

Figure 8. Gross Foreign Assets by Japan (1996-2022)



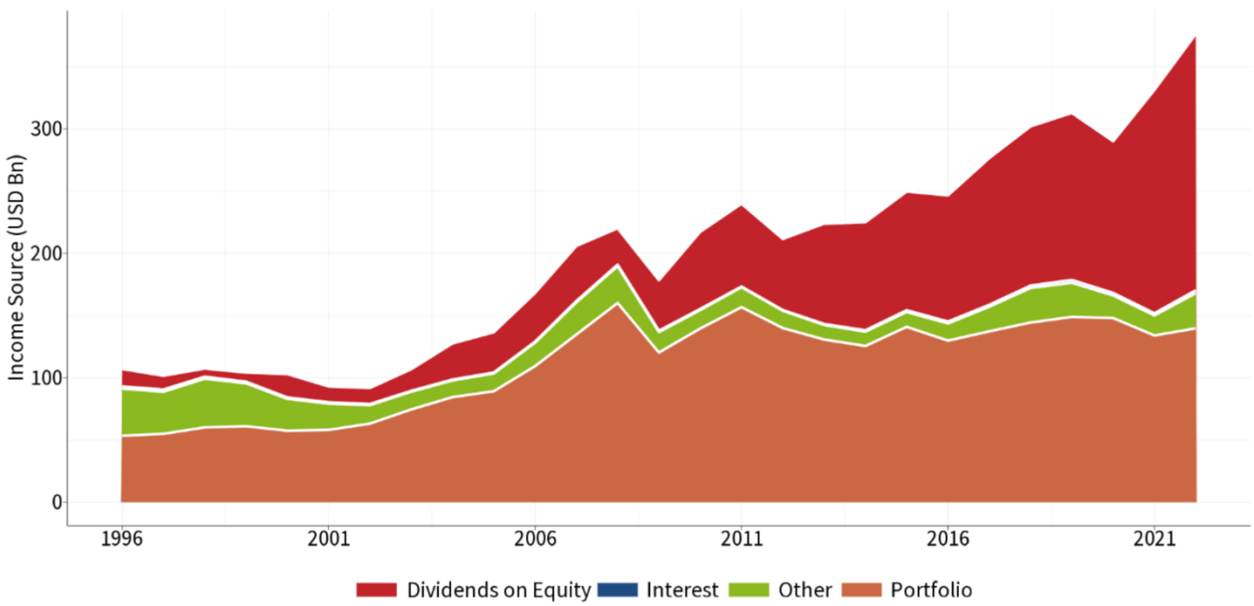
Note: The figure shows the composition of gross foreign assets across time for Japan. Source: Bank of Japan.

Despite representing only 20% of Japan's international investment position, Figure 9 shows that dividends stemming from direct investment abroad, or FDI, account for 55% of the gross primary income of Japan's current account, meaning that the returns on FDI are 2.75 times higher than that of other assets. This was not the case until recently: income from FDI was USD 14 billion in 1996 on an FDI stock of USD 263 billion, representing a 5.3% return. By 2022, returns grew to USD 206 billion on a stock of to USD 2.1 trillion, representing a rate of return of 9.8%.

It is important to note that, as shown in Figure 10, returns to FDI are significantly larger than those of fixed income, portfolio, and other investments. This has been the case for almost every year in the sample, and the gap has grown since the 2008 global financial crisis. An important difference between FDI and portfolio investments is that the latter buy their claims at market prices, while the former deploys money, productive knowledge and capabilities into a subsidiary. Suppose that the return on capital inside the company is 10%. Now suppose the market return for equities is 5%. The FDI investor will realize the 10% gain. But the equity investor in that same firm will only be able to buy the equity at twice the price, so that the return for such an investor remains at 5%. Hence, the excess returns of FDI relative to traded equities is a function of the quality of the knowledge and capabilities that are inside the firm and are not accessible to a financial investor.

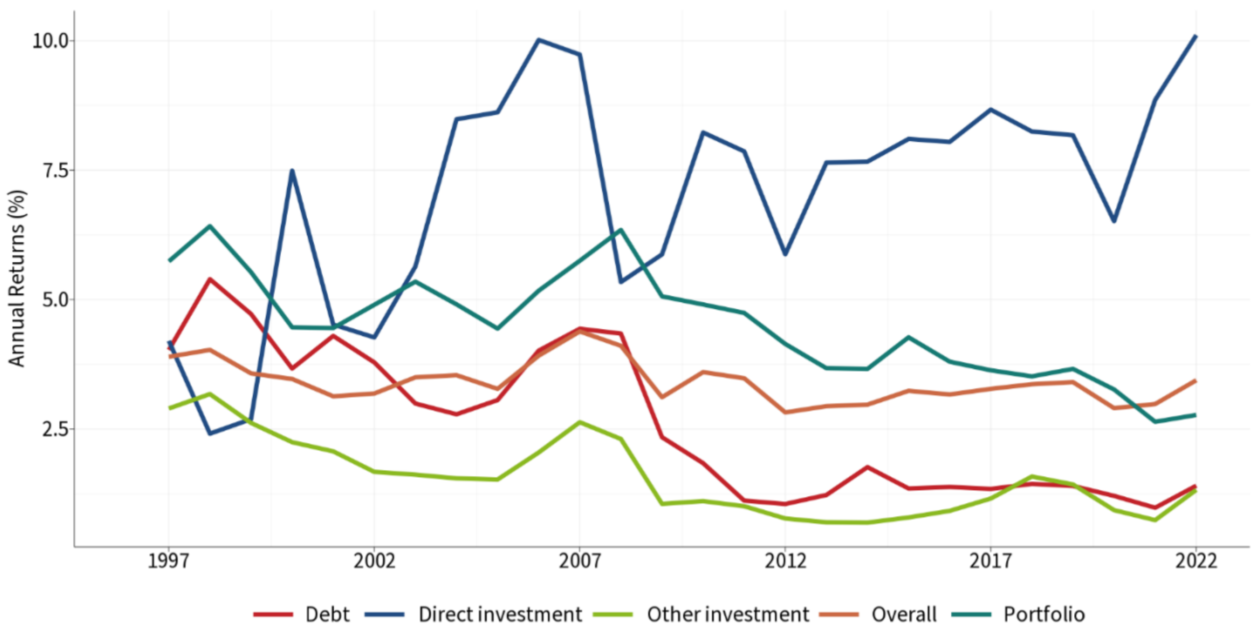
Moreover, to increase FDI by a factor of 8 since 1996 is not an easy feat. It implies that Japanese companies have found many opportunities to deploy their knowledge abroad. Moreover, doing so with high returns is a reflection of the knowledge and capability capital of Japanese firms.

Figure 9. Primary income components (1996-2022) and returns on assets.



Note: This figure shows the composition of gross primary income associated with each type of foreign asset held by Japan between 1996 to 2021. Dividends on equity refers to repatriated income stemming from Japanese FDI. Source: Bank of Japan.

Figure 10. Returns on foreign assets (1997-2022)

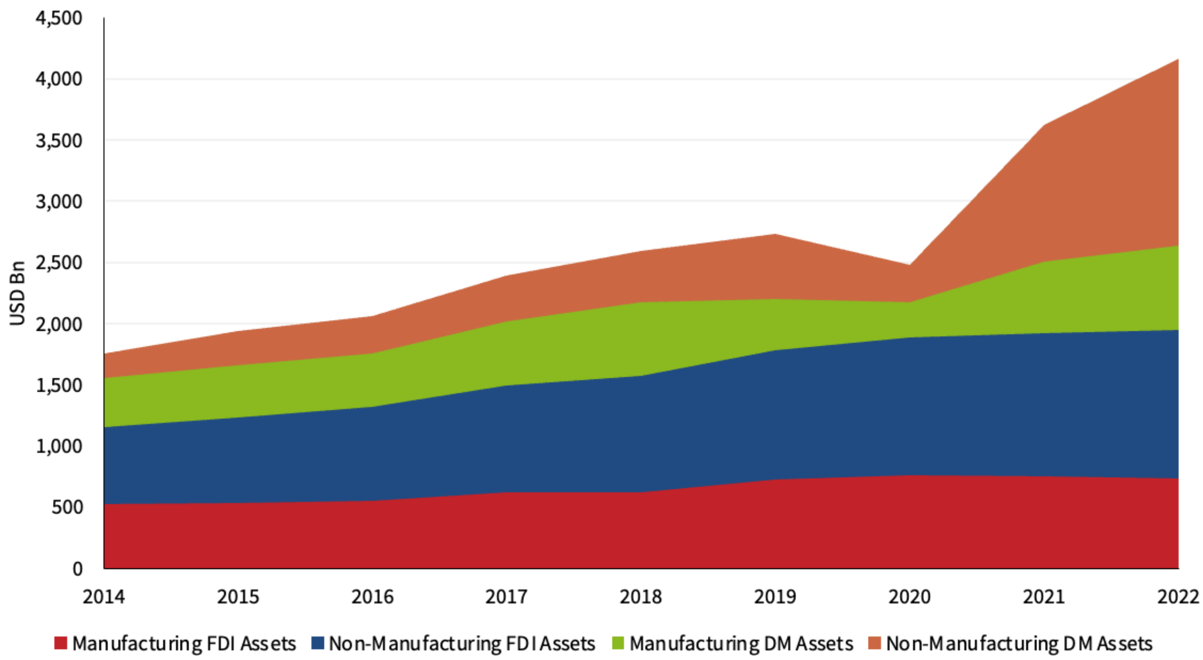


Note: This graph shows the returns over assets of each type of foreign asset held by Japan, computed from accounting lines in the Balance of Payments. Source: Ministry of Finance (Japan); authors' calculations.

An alternative way to measure the knowledge embedded in Japanese assets abroad, resulting in higher-than-normal returns, is by computing Japan's "dark matter" foreign assets, following Hausmann and Sturzenegger (2007). The 'abnormal' high returns for Japanese foreign assets can be explained by the presence of 'invisible' assets that the authors interpreted as the presence of knowledge capital, which explains the apparent excess return on financial capital. As such, we rely on the original methodology from Hausmann and Sturzenegger (2007) to calculate FDI-specific "dark matter" (see Appendix C for a detailed explanation and calculations). Simply put, these assets are the capitalized value of the stream of excess-returns they generate.

When accounting for the 'dark matter' of Japanese investments abroad, the value of outward FDI assets increased from USD 1.7 trillion in 2014 to USD 4.2 trillion in 2022 (see Figure 11). This is an increase of about half of GDP in 8 years (see Appendix C, Figure C1).

Figure 11. FDI and 'Dark Matter' Assets (2014-2022)

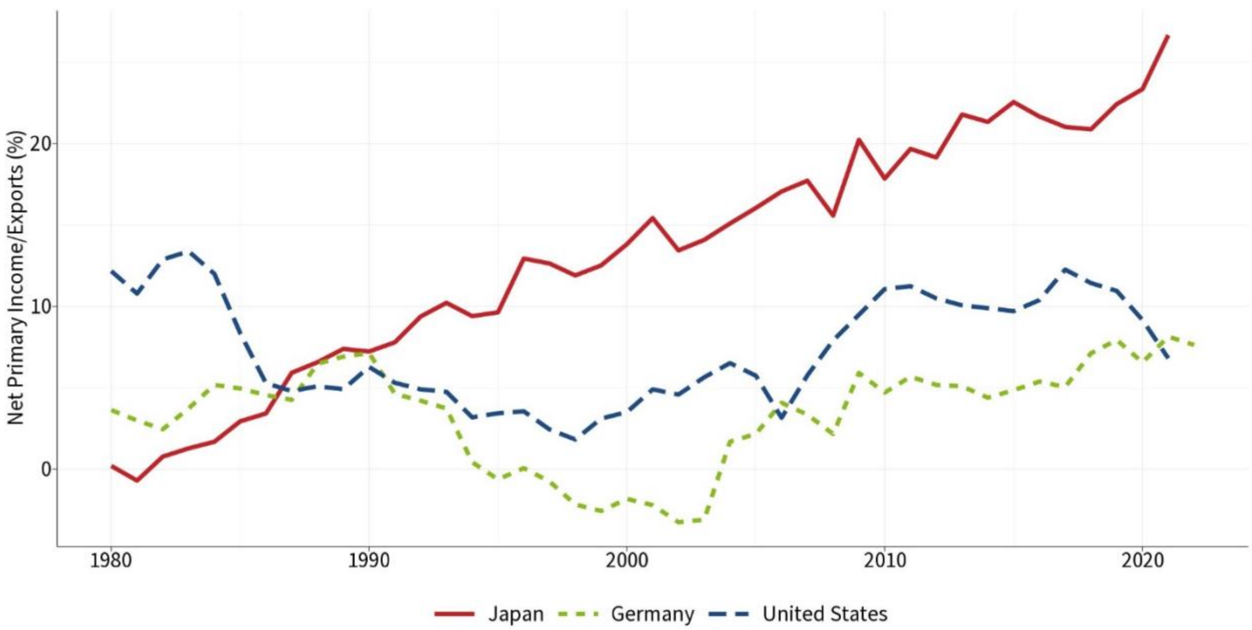


Note: This figure shows the accumulation of 'invisible' or 'dark matter' assets that can explain the higher-than-normal returns on foreign direct investment, following the methodology by Hausmann and Sturzenegger (2007). Source: Ministry of Finance (Japan), Bank of Japan; authors' calculations.

Income from foreign assets has consequently become a crucial aspect of Japan's global economic footprint. In 2022, income from foreign direct investments was equivalent to about 28% of exports of goods and was 29% larger than all exports of services. When looking to all financial income, beyond FDI, net capital income from abroad[4] is equivalent to about half of total exports of goods and represented 2.4 times the exports of services in 2022. The ratio of net capital income to the export of goods and services is shown in Figure 12. Since exports have stagnated and foreign assets continue to grow and are highly profitable, capital income is the most dynamic element in Japan's balance of payments.

[4] Net capital income is the income of Japanese-owned assets abroad minus the income accruing to the foreign owned assets in Japan.

Figure 12. Net primary income as a share of exports of goods and services (%)



Note: This figure plots the evolution of the primary income of Japan as a share of total exports of goods and services over the past 40 years. Source: World Development Indicators, 2023; authors' calculations.

We should note that recent policy initiatives have been aiming to reshore manufacturing. Sakuma (2022) argues that the Japanese government has been offering subsidies designed to slow down or even reversing offshoring. Satoh and Ting-Fang (2024) highlight how subsidies were able to attract investments in the semiconductor industry from TSMC, Micron and Samsung into Japan.

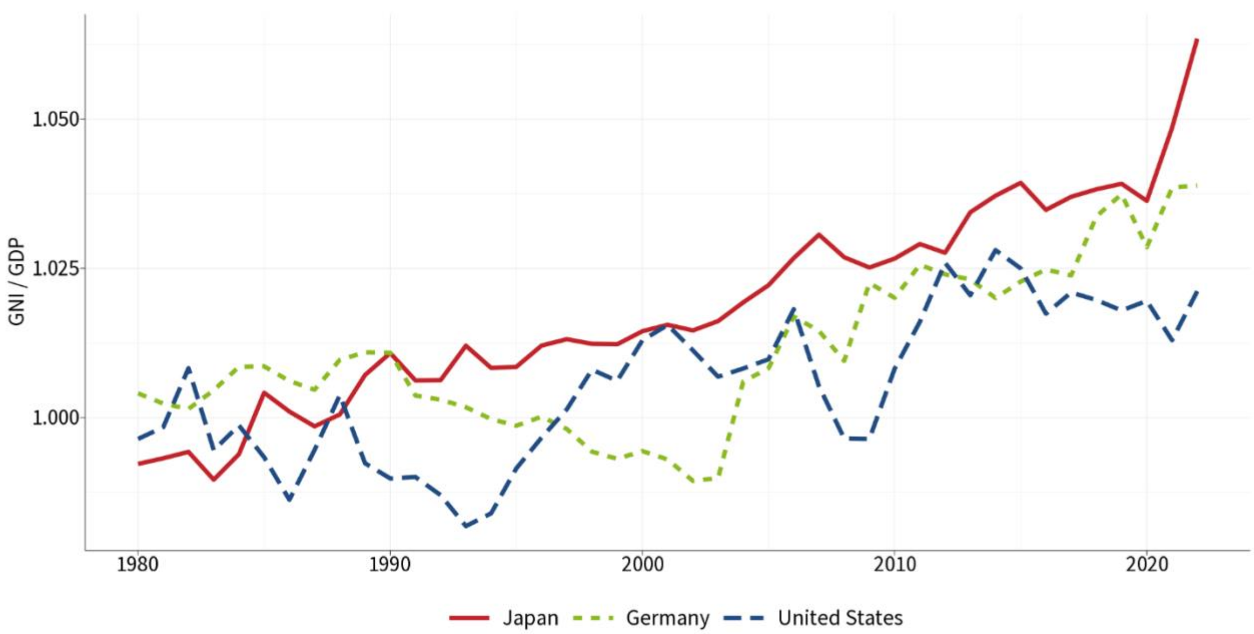
Implications for Productivity and Growth

The natural implication for the documented increase of the activities of Japanese firms abroad and their growing returns is that measuring the aggregate performance of the Japanese economy requires incorporating these activities. As shown in Figure 13, there is a growing gap over the past decades between Japan's Gross National Income (GNI) and Gross Domestic Product (GDP), a gap that is larger than for other industrialized nations such as the US and Germany. Among high income countries, it is the 3rd largest gap after Hong Kong and Norway[5]. As long as the internationalization of Japanese firms through foreign investment continues, we argue, this gap for Japan will keep widening.

[5] In the case of Hong Kong, high net capital income is due to the fact that many foreign companies choose that country as a jurisdiction to domicile their capital. In the case of Norway, it is driven by its large savings of oil income abroad. In contrast, in Japan the gap is due mainly to the large returns on its investments abroad.

We should note that focusing on GNI instead of GDP is not enough to change the picture of relative Japanese stagnation. From 1990 to 2019, GDP per hour worked grew 265% in the US and 166% in Japan[6]. This gap only narrows from 99 to 90 percentage points if we calculate it using GNI instead. That said, in contrast to other economies with a large GNI to GDP gap, Japan's gap stems from the profits of its FDI and not labor income such as remittances, or other forms of direct transfers. Yet profits are only a fraction of economic activity, so the full size of Japanese activities is understated even in GNI statistics[7].

Figure 13. Gross National Income (GNI) to Gross Domestic Product (GDP) ratio



Note: This figure plots the ratio between Gross National Income to Gross Domestic Production in Japan and peers. Source: World Development Indicators, 2023 and authors' calculations.

We find that this dynamic also plays out in firm-level productivity. While aggregate productivity in Japanese firms has increased at an annualized rate of 0.3% since 2012, this growth has been very different for firms with and without activity abroad. To explore this, we collect data from more than 22,000

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[6] Current international dollars, PPP. World Development Indicators.

[7] The GNI to GDP gap is explained by the rise of net primary income, which in turn is significantly associated with growth in inflows from FDI dividends. However, while GDP measures total output, FDI-related inflows only account for profits after taxes from Japanese firms abroad. In Japan, the pre-tax corporate profits to GDP ratio was 17% in 2022. We can assume that the post-tax ratio would be substantially lower. Based on data from the St. Louis Fed, the ratio of post-tax corporate profits to GDP in the United States averaged 9.5% from 2000 to the present. We are interested in this ratio, on average, for Japanese economic activity abroad. If we assume the US ratio as a benchmark, then every dollar in overseas post-tax profits would be associated with around 11.1 dollars in economic activity. Japanese FDI-related inflows were equivalent to 6.5% of GDP in 2022. Thus, Japanese FDI could be indirectly associated with additional output abroad which is equivalent to 72 percentage points of its GDP.

Japanese firms from ORBIS financial data from 2012 to 2021 and use the methodology outlined by Kalemli-Ozcan et al (2015) to create weights and form a nationally representative panel of firms. We use this sample and compute total factor productivity (TFP) for each firm across time (more details in Appendix D)[8]. The left panel of Figure 14 shows that our estimate of aggregate TFP growth using this sample closely resembles the growth in TFP estimated by Penn-World Tables in the period 2012-2019.

The right panel of Figure 14 shows the evolution of TFP for firms with and without activities abroad (as measured by having subsidiaries located in countries other than Japan). As shown, productivity gains in Japan have been concentrated in firms that have subsidiaries outside the country. This result is consistent with the economic literature at large: high productivity levels explain the propensity of firms to expand abroad through direct investment relative to serving foreign markets through exports (Melitz, 2003). The result is also consistent with literature on productivity differences between multinational and non-multinational Japanese firms (Tanaka, 2011). The figure also shows that purely domestic Japanese firms (those *without* a subsidiary abroad) have experienced significant decreases in their productivity during the last decade.

Naturally, there could be many other different explanations and confounding factors explaining these two trends. Table D2 (from Appendix D) shows that the relationship between TFP and having subsidiaries abroad remains robust after controlling for firm's age and size as well as industry.

It is important to explore the difference between industries with a prevalence of subsidiaries abroad relative to those that do not have them. **Figure 15** shows the relative weight of industries with subsidiaries abroad vs those without them. The graph indicates that IT, mining, manufacturing, wholesale trade, finance and educational services are among the industries with an over-representation of firms with subsidiaries abroad. What is clear from the graph is that tradable industries tend to be over-represented in terms of firms with a global presence, while non-tradable industries such as retail, hotels and restaurants, waste management and other services have few subsidiaries abroad.

This suggests that the aggregate productivity puzzle of Japan may be related to the so-called Baumol's cost disease (Baumol & Bowen, 1965). Suppose that productivity growth in tradable activities is very high. This makes the country increasingly wealthier. But consumers enjoy consuming both tradable goods (e.g., energy, garments, electronics, and medicines) and non-tradable goods like healthcare, restaurants, and entertainment. Tradable goods can be imported but non-tradable goods must be produced locally. Therefore, if the tradable sector's productivity grows faster than that of the non-

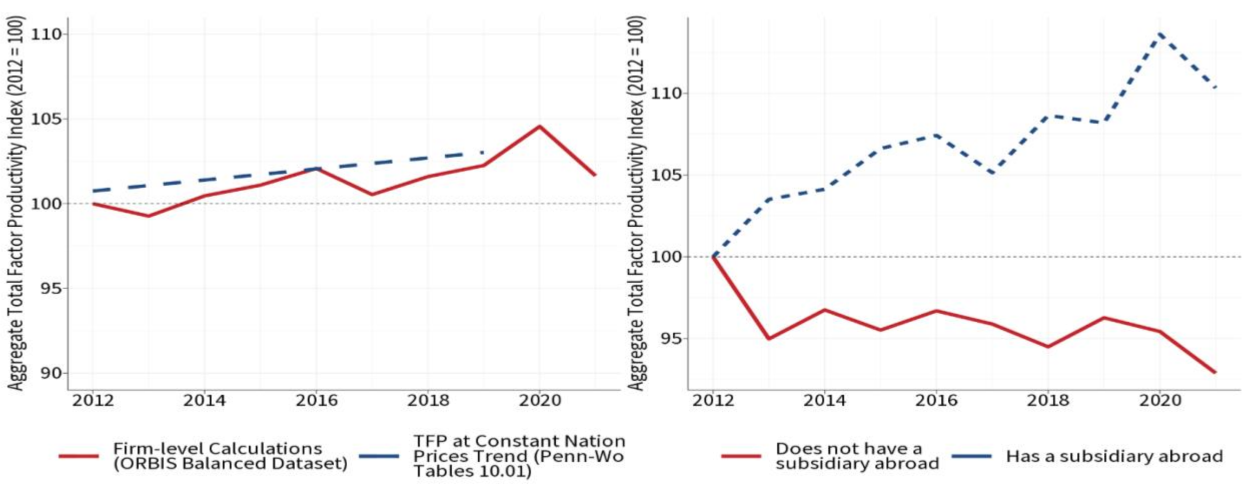
[8] We assume a Cobb-Douglas production function that uses the operating revenue of firms, its fixed assets, and its costs of production, and assign elasticities using the cost share method, following Bahar (2018). For more details see Appendix D.

tradable sector, as the society becomes richer it must assign more workers to non-tradables, i.e. to the sector with low productivity growth.

Figure 16 suggests that this is the case. The graph shows the evolution of the wage bill of internationalization-intensive industries relative to the industries that have very few subsidiaries abroad. Consistent with the Baumol's cost disease, the graph shows that the bulk of the wage bill has been moving increasingly to the industries that are very domestically focused, that Figure 14 has shown suffer from negative productivity growth.

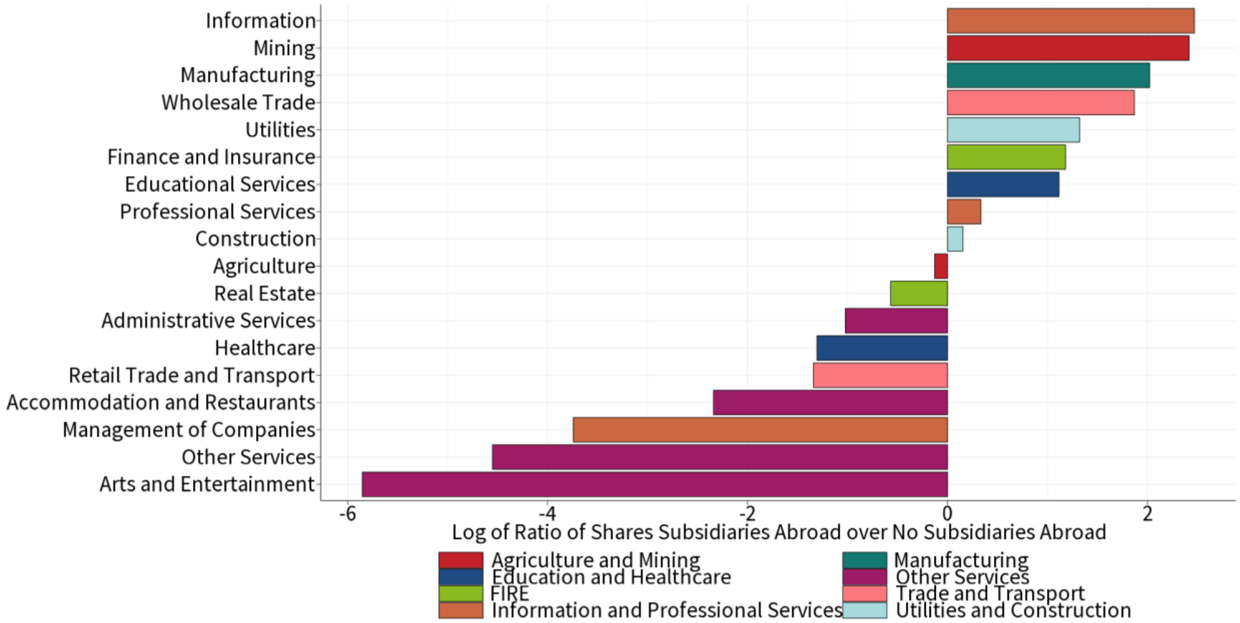
Figures 14-16 are helpful in solving the puzzle of high complexity and low aggregate performance. Japan has many companies with very valuable knowledge, capabilities and technology. These companies have been internationalizing. They have been licensing their IP abroad and have been engaging in direct investments abroad at a high rate and with very high returns. However, they have not been growing in terms of using labor resources. These resources have been moving increasingly to the part of the economy that is not internationalized, which happens to be dominated by non-tradable, low-productivity-growth industries. They do so because non-tradables cannot be imported and rising incomes translate into higher demand for non-tradables and hence with more employment in these industries. By contrast, tradables goods can be supplied from abroad, including from Japanese subsidiaries. The effect is to lower the overall productivity growth of the economy, in spite of the successful growth of productivity in tradables.

Figure 14. Total Factor Productivity Growth (TFP): Aggregate, firms with subsidiaries and with no subsidiaries



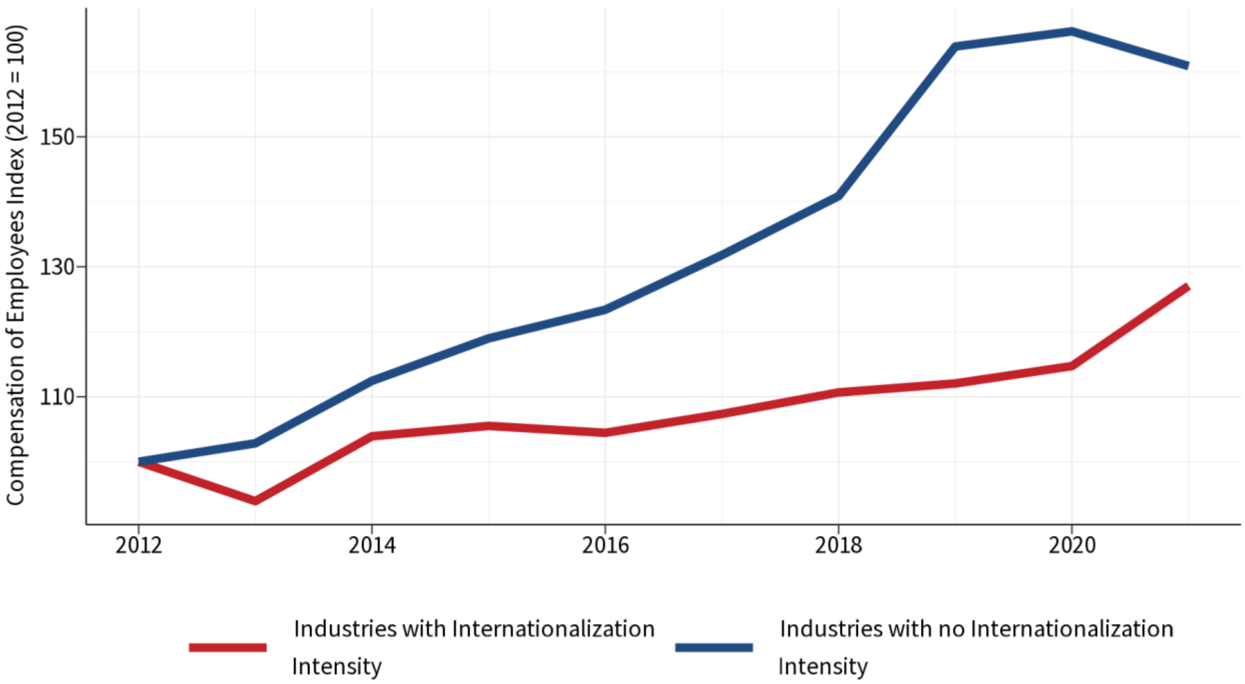
Note: The left panel shows the evolution of aggregate Total Factor Productivity computed using a representative sample of 22,000 Japanese firms (red line), alongside the aggregate TFP trend taken from by Penn-World Tables (dashed blue line). The right panel shows the aggregate TFP using our representative sample of firms for firms with (dashed blue line) and without (red line) a subsidiary outside of Japan. Source: Penn-World Tables 10.01, Bureau Van Dijk, and authors' calculations.

Figure 15, Over-representation and under-representation of industries with subsidiaries abroad.



Note: Graph shows the intensity of the industries on its internationalization (presence of subsidiaries abroad in a firm). The graph is logged so everything above 1 means that is more international than domestic. Below 1 means the opposite. Firms above 1 tend to be in tradable sectors. Source: Bureau Van Dijk and authors' calculations

Figure 16. Worker compensation in internationalized-intensive industries vs domestic-intensive industries



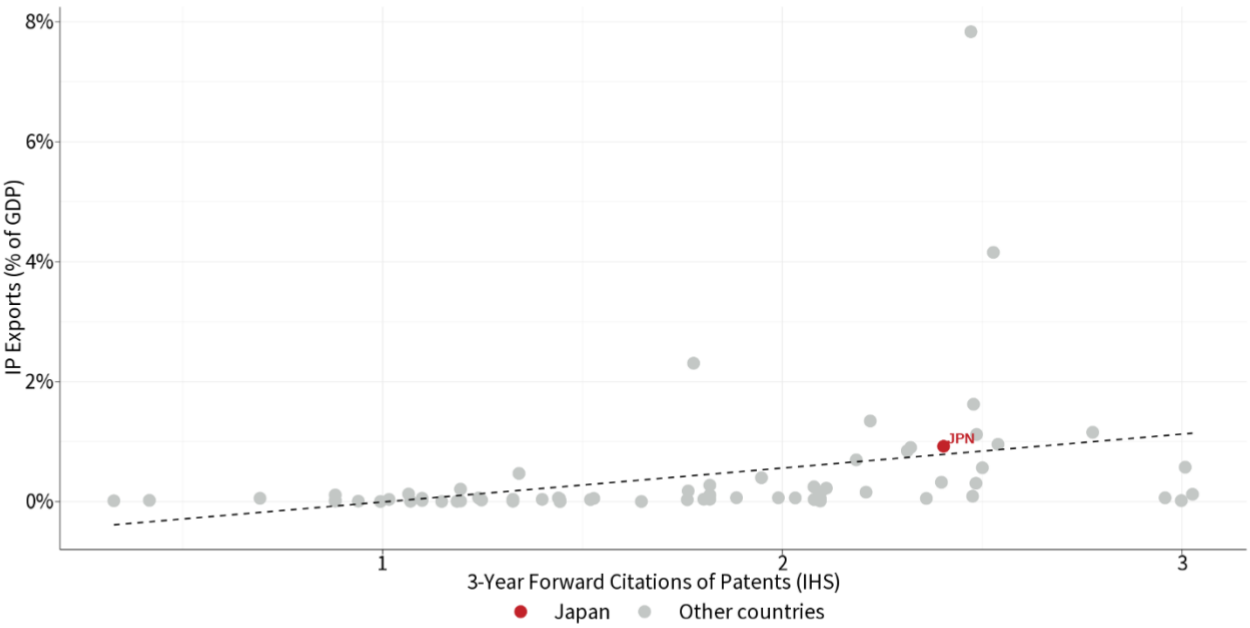
Note: The figure shows the growth of the compensation of employees since the year 2012 classified by the intensity of the internationalization of the industries. Less international industries have been growing faster in the last few years. Source: Bureau Van Dijk and authors' calculations.

A central driver: Innovation

It is fair to assume that one of the central drivers of Japan's high levels of complexity (despite its loss of competitiveness in exports of goods) and, particularly, its increasing return to economic activity abroad is its global leadership in innovation, both in quantity and quality terms. We measure quality as the 3-year forward citations of a country's patents.

In general, countries with higher innovation quality tend to have higher levels of intellectual property (IP) exports, as shown in Figure 17: across countries there is a positive relationship between the level of global IP exports as a share of GDP and the quality of its patenting activity. We find that this relationship is robust to a number of different measures of both global competitiveness and innovation quality (see Appendix E). While this is only a correlation, it suggests the importance of the role that innovation quality plays in the competitive edge that Japanese firms have had abroad and is reflected in its exports of IP-related services and returns to investments abroad. This underscores the importance of a healthy and constantly improving innovation sector that allows the country to remain competitive in international markets.

Figure *17*. The relationship between quality innovation and IP Exports (% of GDP)

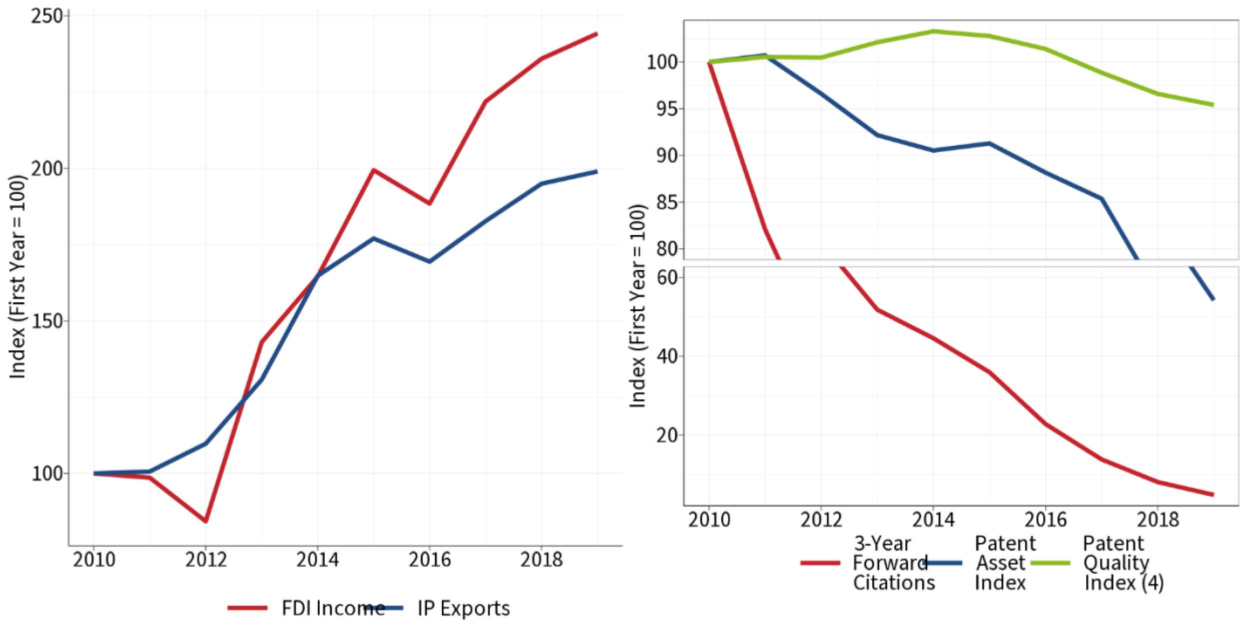


Note: These graphs show the correlation between IP Exports as a share of GDP and countries' innovation quality. Tax havens (Luxembourg, Ireland, Cyprus, and Malta) are excluded from the graph. Countries above 2% of GDP of IP exports are the Netherlands, Switzerland, and Singapore. Source: WTO, PATSTAT, OECD, authors' calculations.

To the extent that the success of the Japanese economy in the global arena relies on the quality of its innovation –as suggested by the relationship above—we underscore a serious risk. While the IP exports and income from FDI –two important indicators of Japan's success abroad— have continuously increased in the last ten years, the quality of innovation in Japan –as measured by several different metrics - have been on a declining trend. Whether we measure patent quality by forward citations or using the OECDs patent quality indicators (PatentSight and PATSTAT)—Japan has experienced a significant decline in patent quality in the last few years (see Figure 18). Note that, as shown by Bahar and Strauss (2020), the lower level and decline in patent quality for Japan is more pronounced than for other industrialized nations such as the US and Germany.

As such, to remain competitive in international markets, Japan must increase its focus on taking measures to improve the quality of its innovative activities at home. Emphasizing the need for a shift towards more globally collaborative research and development (R&D) efforts is crucial, which we discuss more in detail in the final section.

Figure 18. Evolution of IP Exports, FDI Income, and Innovation Quality Metrics (2010-2019)



Note: The left panel shows the increase in FDI income and IP exports as a share of GDP in the last decade, while right panel shows the decline in several patent quality measures in the same time span. The vertical in the right panel has been adjusted for visualization purposes. Notes: The Patent Asset Index should be considered as a stock of active patents, which results in a decline when the quality of current patents is not able to compensate for the expiration of older ones. Source: WTO; PatentSight; PATSTAT; authors' calculations.

Conclusion and Policy Implications

We started this paper with a puzzle: How is it that Japan under-performs the US and Germany in terms of growth of GDP and productivity, but is consistently ranked as the most complex economy in the world? Why is this happening despite falling export market shares across almost all industries, an indication of declining competitiveness? We end with a potential solution to this puzzle. Japan does have a remarkably effective knowledge-intensive industrial sector, especially in tradable activities, but it faces a stagnant / dwindling labor force. This sector exhibits relatively high productivity growth, but Japanese firms have realized that their knowledge can create much more value if it can be implemented elsewhere, where labor and other assets are more abundant. As a consequence, Japan has been licensing its technology abroad, representing 38% of US Intellectual Property (IP), but the US represents only 20% of all of its IP sales abroad. In addition, Japan has been successfully investing abroad. The quality of the technology of Japanese firms gets reflected in the large amounts of FDI outflows coupled with very high returns. We estimate that including the 'dark matter' value of Japanese investments abroad, outward FDI assets increased from USD 1.7 trillion in 2014 to USD 4.2 trillion in 2022, an increase of about 50% of Japan's 2022 GDP in 8 years (see Figure 11).

However, as this growth process takes place, Japanese consumers demand both more tradables and non-tradables. Tradables can be imported, and Japan generated ample foreign exchange to do so, non-tradables have to be produced locally, leading a a movement of labor from the high productivity / high productivity growth tradable sector to the low productivity / low productivity growth non-tradable sector. This process is made more intense by the stagnant / falling labor force. This so-called "Baumol's cost disease" is particularly more intense in Japan because of its successful generation of valuable knowledge in the context of a stagnant or declining labor force.

Clearly, this problem may be made less severe with innovations that would enhance the productivity of non-tradable activities and with an immigration policy that may change the downward trend in labor supply.

However, we also show that, while the international presence of Japan has been strengthening and has remained strong, measures of the quality of its innovation have been trending down. This calls into question the sustainability of current trends. Our findings indicate a decline in the quality of Japanese innovation, despite its high volume, a trend that may pose significant risks to Japan's continued leadership in the global knowledge economy.

To counteract this trend, we advocate for strategic policy interventions aimed at enhancing the quality of innovation. These include a hybrid model for financing research and development (R&D) that combines subsidies for all firms engaging in R&D with targeted investment in high-potential projects (Bahar & Strauss, 2020). Such an approach would encourage risk-taking with public funds in areas the private sector may avoid.

Furthermore, integrating Japan's innovation ecosystem more deeply into the global economy is imperative (Bahar & Ozdogan, 2021). Facilitating greater collaboration between Japanese inventors and their international counterparts, coupled with policies that attract foreign R&D investment, is crucial. Additionally, revising migration policies to expand Japan's labor force, particularly in knowledge-intensive sectors, could significantly enhance the nation's innovation quality. In a world where there is global competition for talent, policies that enable Japanese firms to attract skilled foreign workers could prove crucial in sustaining this competitive edge against developed peers and fast-growing emerging economies. As such, encouraging the influx of global talent into Japan's innovation system offers a pathway to sustained economic vitality and growth (Bahar et al., 2023). Despite recent efforts to boost skilled migration – such as the introduction of the Specified Skilled Worker visa in 2019 – data from the World Bank's World Development Indicators show that Japan's yearly net immigration flow as a share of population has remained stagnant since the mid-2000s, at a level that is less than half that of United States and Germany relative to their populations.

In conclusion, Japan's challenges are in part the consequence of its success in knowledge creation in an economy with a stagnant labor force. The road ahead requires careful navigation of demographic and economic trends, with a concerted focus on reinforcing Japan's role as a leader in global innovation as the fuel to keep the Japanese economic engine running faster and for much longer.

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Appendix A: Concepts from Economic Complexity

▪ Revealed Comparative Advantage (RCA): This is a place-product measure that captures the relative importance of a product in a place. Following the methodology of Balassa (1964), it is usually calculated as the ratio between the proportion of the product in the export basket of a place and the proportion of the product in world trade. If this relationship is greater than one, the place has a "revealed comparative advantage" in that product, which is equivalent to saying that the place produces the product more intensively than the rest of the world.

▪ Diversity: This is a place-specific measure of the number of products or industries for which a place has an RCA greater than one. It is a quantity that can be compared from one place to another. The diversity of a place captures how many different economic activities are present but does not imply anything about the complexity of those activities. Higher diversity implies a broader adoption of technology and a greater diversity of skills. Greater diversity implies less vulnerability to negative shocks to any particular market. It also implies more freedom for individuals to pursue different career opportunities.

▪ Product Complexity Index (PCI): This is a product-specific statistic that measures the knowledge intensity of a product. The measure is based on how ubiquitous is the product (the number of countries with comparative advantage in it) as well as how diversified are those countries. The most complex products include sophisticated machinery, electronics and chemicals. The least complex products are agricultural and mineral raw materials.

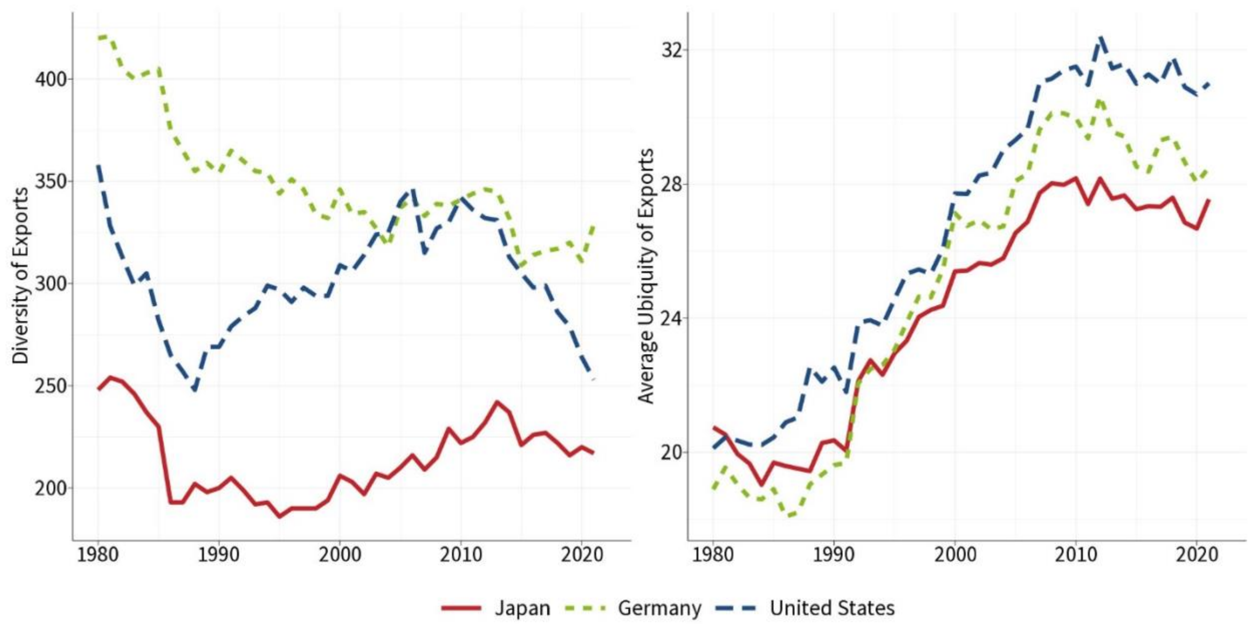
▪ Economic Complexity Index (ECI): This is a place-specific measure that captures how complex a place's production/export basket is. It is calculated as the average PCI of the products in which the country has comparative advantage. Therefore, it reflects how much productive knowhow a place possesses. The most complex countries include Japan, Switzerland, South Korea, and Germany. Meanwhile, the least complex countries (that are concentrated in few products that most countries in the world can produce) include Guinea, Angola, Burkina Faso, and Nigeria.

▪ Complexity Outlook Index (COI): This is a place-specific measure that evaluates how many complex products are near a place's current set of productive capabilities. The COI captures the ease of diversification for a place, where a high COI reflects an abundance of nearby complex products in which the country does not yet have comparative advantage. A low complexity outlook indicates that a place has few unexploited products that are in the vicinity of its current production, making further diversification more challenging. Some countries have low COI because they are poorly diversified in low complexity, poorly connected products. Other countries have low COI because they are highly diversified and have already acquired comparative advantage in many of the most complex products, meaning that diversification will require innovation at the technological frontier.

Appendix B: Evolution of Japan's Economic Complexity

Japan has the highest Economic Complexity Index (ECI) in the world since 1981 – when it surpassed Germany – according to data from the Atlas of Economic Complexity (The Growth Lab at Harvard University, 2023). Two main characteristics explain how Japan remains a highly complex economy: Japan's export basket has a relatively low diversity, but those goods are less ubiquitous and more sophisticated than those of other advanced countries such as Germany and the United States (see Figure B1).

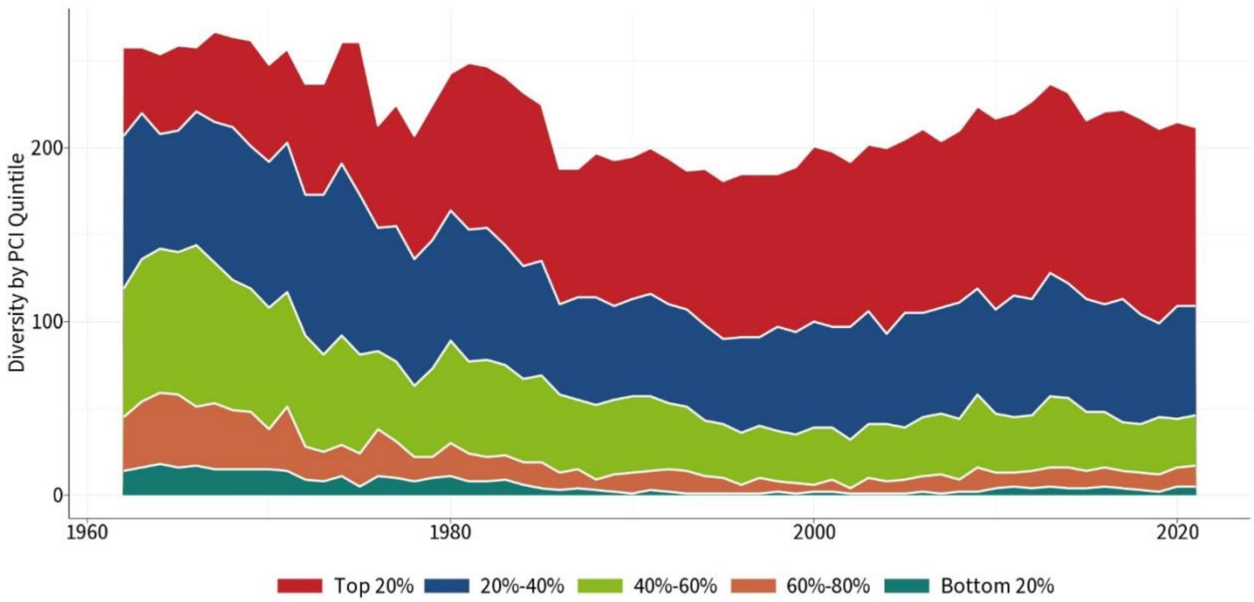
Figure B1. Diversity and Ubiquity of Exports (1980-2021)



Note: The left panel shows the evolution of the diversity of exports in Japan, United States and Germany. The right panel shows the evolution of average ubiquity for the industries in which each country's has a revealed comparative advantage. Source: Atlas of Economic Complexity; authors' calculations.

Japan's export basket experienced a notable transformation during the second half of the twentieth century. In 1962 Japan had a diversity of 258, including 57 industries in top quintile of the PCI distribution. By 2000 Japan had a diversity of 201, including 104 industries with a PCI in the top quintile. Hence, the proportion of industries within the top complexity quintile in Japan's export basket rose from 22.1% to 51.7% over those four decades, as shown in Figure B2.

Figure B2. Diversity by PCI Quintile (1960-2021)



Note: The figure shows the diversity of Japanese exports, decomposed by the quintile to which each industry/product corresponds to in the distribution of all industries/products by their Product Complexity Index. Source: Dataverse, Atlas of Economic Complexity; authors' calculations.

During this transition, Japan specialized in new complex industries but also lost competitiveness in others of lower complexity. We define these "lost industries" as those in which Japan had a revealed comparative advantage for at least 10 years in the sample but not in the most recent year. From 1962 to 2021, Japan lost 190 industries out of the 394 in which it once had a revealed comparative advantage.

Table B1. Industries lost by PCI decile and sector (1962-2021)

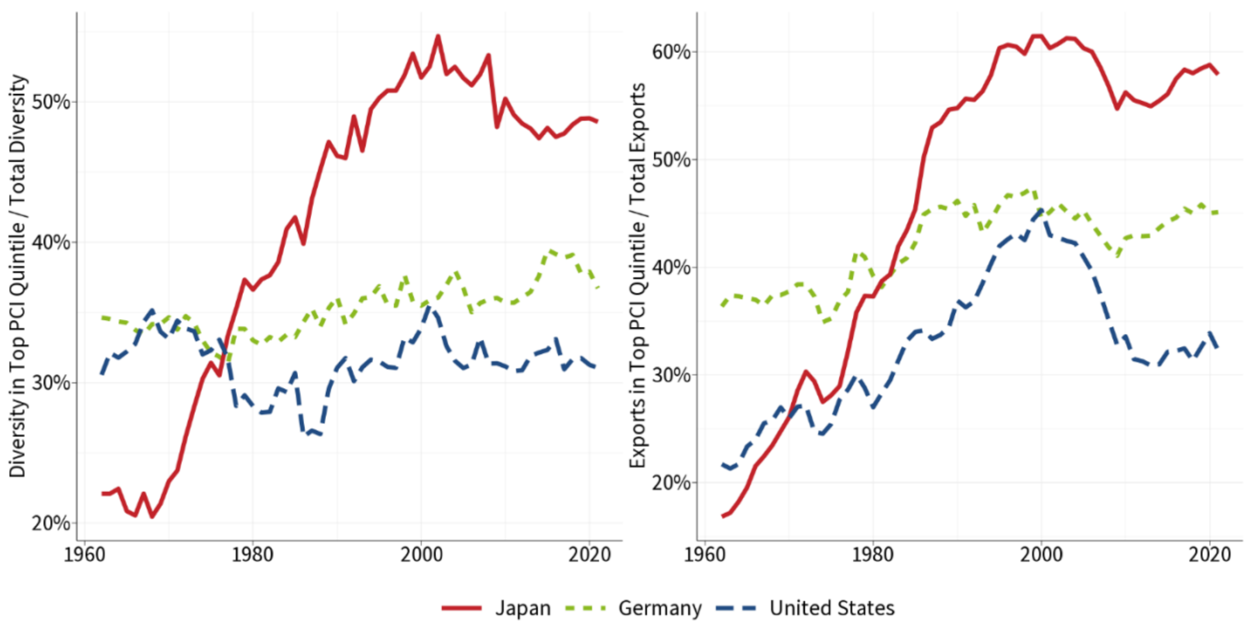
PCI Decile	Lost Industries	Hist. Presence	Loss %	Sector	Lost Industries	Hist. Presence	Loss %
Top 10%	11	69	15.9	Rubber & Leather	3	13	23.1
10%–20%	17	64	26.6	Chemicals	20	58	34.5
20%–30%	26	60	43.3	General Machinery	37	99	37.4
30%–40%	20	44	45.5	Electric Machinery	9	24	37.5
40%–50%	23	40	57.5	Metals	26	65	40.0
50%–60%	27	36	75.0	Transport Equipment	10	20	50.0
60%–70%	17	26	65.4	Other	16	29	55.2
70%–80%	23	26	88.5	Lumber & Pulp	4	5	80.0
80%–90%	19	22	86.4	Textiles	53	65	81.5
Bottom 10%	7	7	100.0	Food	12	13	92.3

Source: The left side of the table decomposes industries lost by the PCI decile to which each of them correspond to in the wider distribution of PCI. These are compared to the number of industries in which Japan had "historical presence", defined as having a revealed comparative advantage for at least 10 years of the sample. Loss % is defined as the proportion of lost industries to industries with historical presence in each category. The right panel shows a similar comparison by sector. We binned SITC codes into the same sector classifications used by the Japanese Ministry of Finance when reporting outward FDI by sector. Atlas of Economic Complexity; authors' calculations.

Table B1 summarizes the composition of lost industries by their sector and their PCI decile. The relationship between complexity and the proportion of industries lost is clear. 62% of industries below the 80th PCI percentile was lost, compared to only 21% of above the 80th PCI percentile.

The spectacular rise in the proportion of highly complex products in Japan's export basket was a rare phenomenon. In contrast, peer countries such as the United States and Germany showed relative stability in the metric, as shown in Figure B3. By 2000, industries within the top PCI quintile accounted for 51.7% of Japan's diversity and 61.2% of their export volume, compared to 22.1% and 16.8% in 1962 respectively. Although these proportions have declined after the year 2000, Japan is still the world's leader in both metrics.

Figure B3. Diversity and Exports Shares of the Top PCI Quintile (1962-2021)



Note: The left panel shows the evolution of the proportion of industries from the top quintile of the PCI distribution, within each country's diversity. The right panel shows the evolution of the export volume associated with those industries as a share of the total export volume of each country. Source: Atlas of Economic Complexity

The rise in Japan's Economic Complexity Index is consistent with the evolution of Japan's Complexity Outlook Index (COI). The COI measures how well-positioned a given country is to diversify into more complex existing products, given its current set of capabilities. Japan had a COI of 2.26 in 1962, which was the fifth highest in the world. By 2000 its COI was 0.26, and in 2021 it was -0.44. This characteristic is typical of highly complex economies such as Germany.

This low COI indicates that Japan has already developed comparative advantage in most existing complex products and cannot continue its transformation by just adopting technologies that already exist somewhere else in the world. Progress will require innovation at the technological frontier.

Appendix C: Dark Matter – Framework & Decomposition

Hausmann and Sturzenegger (2007) introduce the concept of "Dark Matter" in the context of international macroeconomics. The term is borrowed from astrophysics, where it denotes unseen matter that is inferred from its gravitational effects on visible objects. Analogously, dark matter assets refer to unrecorded, intangible assets that are accumulated by a country abroad through the co-export of their knowhow and expertise alongside regular financial flows. Despite their invisibility in traditional accounting of a country's International Investment Position (IIP), dark matter assets can yield stable future income flows. They are offered as an explanation for how the United States can exhibit a persistent net primary income surplus while having an IIP of negative USD 16 trillion.

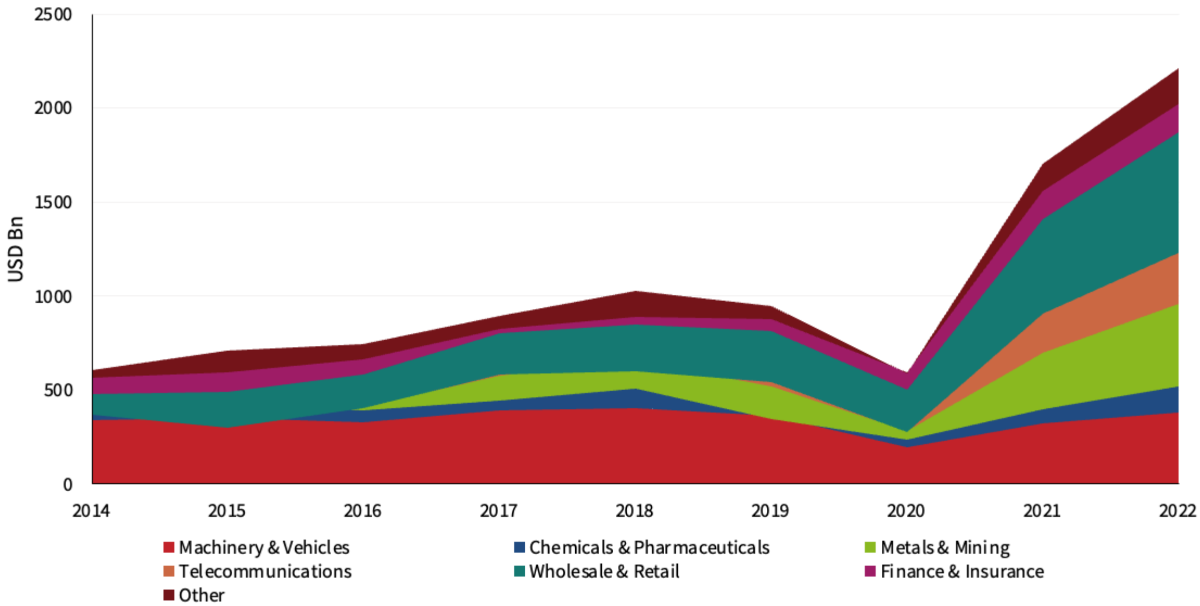
Dark matter assets are estimated by assuming a benchmark natural rate of return that capital should yield in the absence of additional factors. We infer that for investments consistently yielding returns above this natural rate, inventors contributed something more than mere capital – specifically, knowhow. Excess returns are attributed to a hidden stock of dark matter assets that is assigned to the investor country, and correspondingly as dark matter liabilities to the recipient country. Conversely, when investments yield returns below the natural rate, it is assumed that the investor is acquiring knowhow embedded in the investment from the issuing country.

Using data from the World Development Indicators, we approximated each country's IIP as the accumulated sum of their current account balances and compared it with observed net primary income flows. Assuming a natural rate of return of 5%, we estimate dark matter for 163 countries and Japan ranks second, behind United States. France, Germany, United Kingdom and Italy follow. In contrast, China holds the largest amount of dark matter liabilities followed by Ireland, Singapore and Russia.

We also leveraged data from the Japanese Ministry of Finance, which disaggregates their IIP by type of investment and – in the case of FDI investments – by 12 manufacturing industries and 10 non-manufacturing industries. The data also includes repatriated income associated with FDI positions abroad by industry. We used it to calculate outward FDI-specific dark matter for Japan from 2014 to 2022. Figure 12 shows the evolution of FDI dark matter assets and FDI observable assets, decomposed into manufacturing and non-manufacturing.

Additionally, Figure C1 zooms into FDI dark matter on a more granular level. Industries are grouped into 7 categories for ease of visualization. Although machinery & vehicles used to be the largest category a decade ago, the significant post-pandemic rise in dark mater assets has been mostly associated with non-manufacturing industries such as wholesale & retail, telecommunications, finance & insurance, and mining. Within manufacturing, "iron, non-ferrous and metals" showed the largest growth.

Figure C1. Dark Matter Assets by Sector (2014-2022)



Note: The figure shows the evolution of Japanese outward FDI-related Dark Matter, decomposed into 7 industry categories. Source: Ministry of Finance of Japan; authors' calculations.

Appendix D: Measuring Firm-level Productivity.

The methodology for this analysis is designed to rigorously evaluate the productivity dynamics within the Japanese economy, drawing from methodologies explained by Kalemli-Ozcan et al (2015) to build nationally representative databases and from Bahar (2018) to compute productivity measures using ORBIS financial data with heterogeneity across industries. The process begins with the careful integration of data from the Orbis database, with specific adjustments made to ensure the analysis is as representative and accurate as possible.

Data Preparation

The dataset is refined to include only firms with available financial data over the period 2012 to 2021, ensuring consistency in the temporal analysis. This criterion aligns with the methodological rigor demonstrated in the referenced papers, emphasizing the importance of consistent data coverage across time for robust economic analysis. The final sample comprises over 22,000 firms, indicating a substantial breadth of data that enhances the representativeness of the findings.

Weights are calculated using employment shares per industry and firm size, sourced from OECD data on firm size and broad industry classifications. This step is crucial for aligning the firm-level data with the broader economic context, ensuring that the analysis accurately reflects the structure and dynamics of the Japanese economy.

For this analysis, the financial data utilized from these firms is the operating revenue, the fixed tangible assets of the firm, and the costs related to the production of the firm, which includes the costs of employees, number of employees and the cost of materials for production. Only firms that have all this information available in the period are kept in the sample.

Total Factor Productivity Estimation

A key part of the analysis involves using Orbis subsidiary information to identify whether a company has a subsidiary abroad. Firms are grouped based on this characteristic, enabling a comparative analysis of productivity dynamics between firms with and without international subsidiaries.

To estimate Total Factor Productivity (TFP) at the firm level, elasticities at the broad industry level (2-digit) are estimated, assuming a Cobb-Douglas production function and estimating using Ordinary Least Squares (OLS) of a log-transformation of the following equation:

$$Y_i = A\ K^{\beta K} wL^{\beta L} M^{\beta M}$$

Where Y is represented by the operating revenue of the firm, A is TFP, K represents the fixed tangible assets, wL is the cost of employees and M is the cost of materials of each of the firms.

The methodology employed in this analysis offers a robust framework for exploring the intricacies of productivity across Japanese firms. By meticulously adjusting for industry specificity, firm size variations, and internationalization, the analysis provides valuable insights into the economic forces shaping firm performance and sectoral productivity trends.

Finally, the TFP computed in the previous steps is aggregated to get aggregate dynamics for the Japanese economy. Afterward, the same TFP aggregates are computed for the samples of firms with and without a foreign subsidiary. This allows to understand the dynamics of firms that have managed to internationalize versus those Japanese firms that have remained local in their production scope.

As can be seen in the first column of Table , there is a productivity premium for those firms that internationalize their operations, which is not explained by the size of their employment, the industry, or the age of the firm. Similarly, the second column of Table D2, shows that firms that internationalize their operations also experience faster 1-year growth rates that are not explained by the industry, the size of their employment and the age of the firm.

Table D1. TFP premium and TFP growth rate premium on internationalization controlling on industry, size, and age.

	TFP	Growth Rate TFP
With Foreign Subsidiary:	0.040**	0.003***
	(0.012)	(0.001)
Log Employees	0.039***	-0.002***
	(0.004)	(0.000)
Log Age	-0.089***	0.001+
	(0.007)	(0.001)
Observations	208472	187675
R2	0.942	0.006
Year FE	Yes	Yes
Industry FE	Yes	Yes

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001

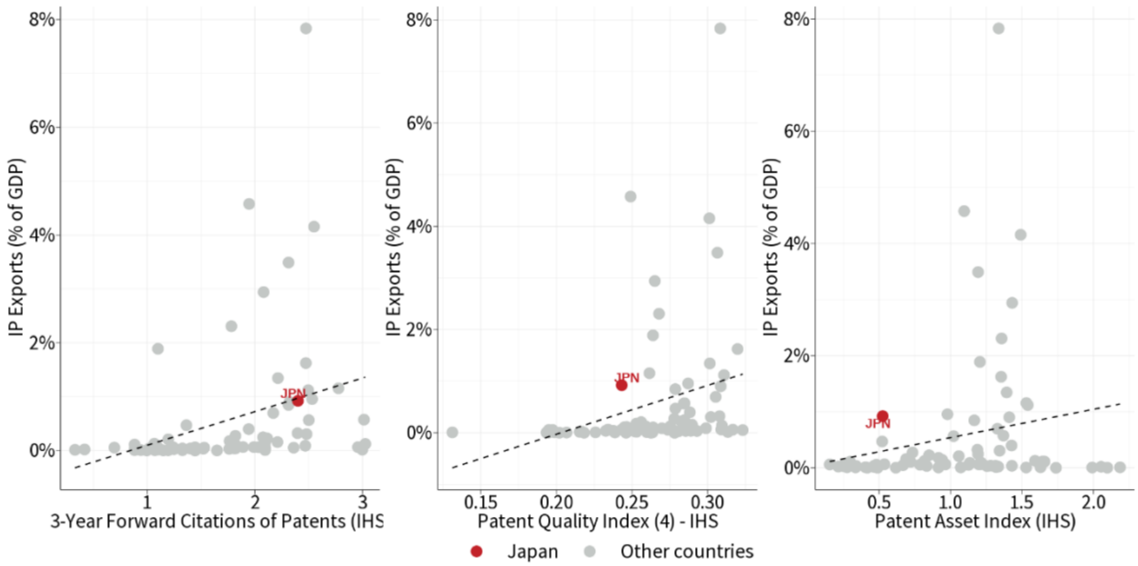
Appendix E: Innovation Quality Measures

These are some useful definitions for innovation quality metrics that allow to evaluate the performance of Japan's patenting efforts in cross-country and across time comparisons:

- Forward Citations: Refer to the count of citations a patent or academic paper receives within t years following its publication. This metric is used to gauge the impact and relevance of the work within a relatively short timeframe after its release. In the context of economics, it can be an indicator of technological advancement, innovation trends, or the research's immediate influence and utility in a given field.
- Patent Quality Index 4: It is an indicator that tries to capture the technological and economic value of innovations, in this case based on number of forward citations (5-years forward citations), patent family size, number of claims and the patent generality index. For the computation of this index, only granted patents are covered (Squicciarini et al., 2013).
- Patent Family: Collection of patent applications and grants that cover the same or similar technological content and are filed in multiple countries or jurisdictions to protect an invention internationally. These related patents are linked through one or more priority applications filed at a national patent office or under a treaty.
- Generality Index: Measure used to assess the breadth of impact of a patent. It quantifies the diversity of fields that cite a given work after its publication. A higher Generality Index indicates that the work has been cited by a broader range of disciplines or technological areas, suggesting its wide applicability and interdisciplinary importance. This metric is calculated based on the distribution of citations across different fields, with more uniform distributions leading to higher values.
- Patent Asset Index: The Patent Asset Index of patents is defined as the aggregated value of all the patents the portfolio contains, in this case the portfolio of patents created in Japan. This value is defined by the aggregation of the Competitive Impact of the individual patents in the portfolio. The Competitive Impact of a patent is calculated using the Technology Relevance and the Market Coverage of the patents (Ernst & Omland, 2011).
- Technology Relevance: Measure based on forward citations and measures whether a patent has been more often cited than other patents from the same technology field and year. It takes into account the number of citations, how old are the citations, and citation rules followed by the international patent offices.
- Market Coverage: is an indicator that shows the size of the global market that a patent family protects.

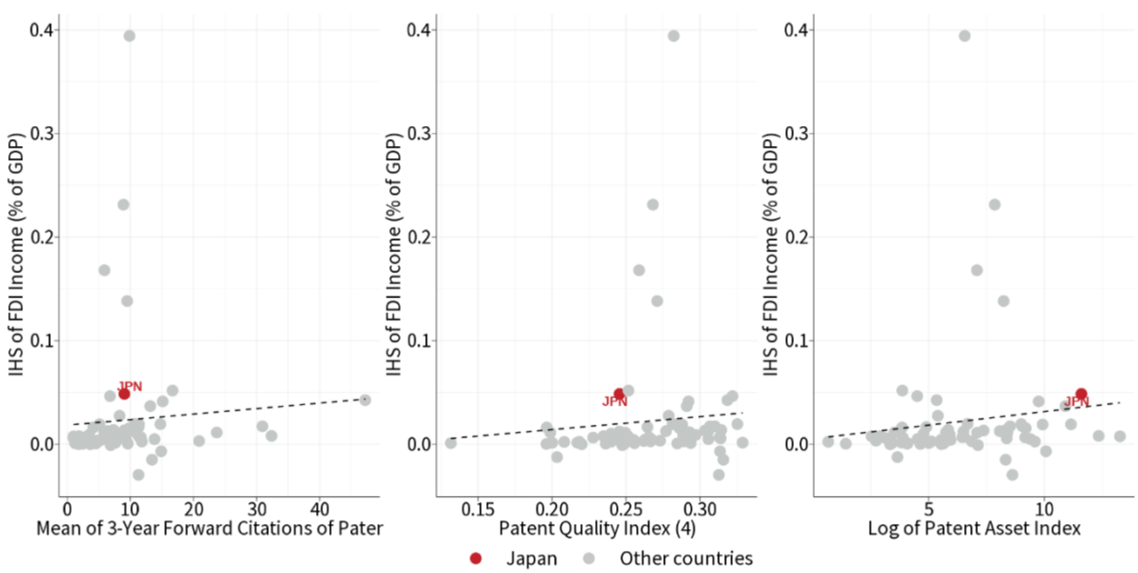
These innovation quality measures have a positive correlation with several metrics that reflect Japanese comparative advantage in exporting its know-how through its foreign subsidiaries, such as IP exports, FDI income and 'dark matter' (see Figure E1, E2 and E3). It is important to note that outliers in the graphs are mainly countries that are considered tax havens, such as Luxembourg, Malta, and Ireland. The reason for this is that firms tend to concentrate their patent filings in the headquarters and offices that are established in these places.

Figure E1. IP Exports and Innovation Quality Indicators



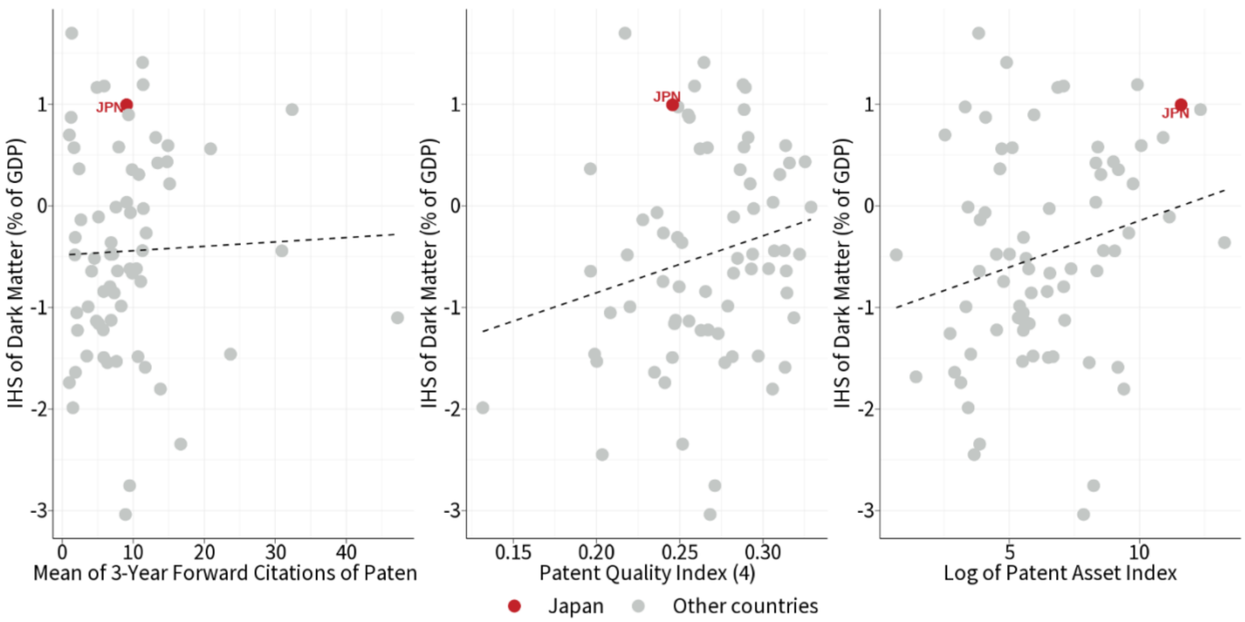
Notes: These graphs show the correlation between IP Exports as a share of GDP and the innovation quality of countries. The Patent Asset Index is calculated by PatentSight, normalizing patent citations by technology class, year, and authority office practices. Source: WTO; PatentSight; PATSTAT; OECD; authors' calculations.

Figure E2. FDI Income and Innovation Quality Indicators



Notes: These graphs show the correlation between FDI Income as a share of GDP and the innovation quality of countries. The Patent Asset Index is calculated by PatentSight, normalizing patent citations by technology class, year, and authority office practices. Source: IMF; PatentSight; PATSTAT; OECD; authors' calculations.

Figure E3. Dark Matter and Innovation Quality Indicators



Notes: These graphs show the correlation between 'Dark Matter' assets as a share of GDP and the innovation quality of countries. The Patent Asset Index is calculated by PatentSight, normalizing patent citations by technology class, year, and authority office practices. Source: IMF; PatentSight; PATSTAT; OECD; authors' calculations.