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REPAYING THE NATIONAL DEBT: POST-PANDEMIC PROSPERITY THROUGH BUSINESS MODEL INNOVATION AND PRODUCTIVITY GROWTH

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Post-Pandemic Prosperity through Business Model Innovation and Productivity Growth

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ABSTRACT

The COVID-19 pandemic will result in a significant rise in debt to GDP ratios among all major economies. The conventional methods of reducing the debt to GDP ratio such as tax rises, inflation, low interest rates and budget surplus are less likely to be effective. We posit that rapid productivity growth offers the only viable option and that it can reduce the debt to GDP ratio to pre-pandemic levels much faster than otherwise. We propose that recent developments in digital technology offers the opportunity to accelerate productivity growth through business model innovation. We propose policies which encourage business model innovation.

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I. INTRODUCTION

Productivity growth in advanced economies has been declining in recent years (Brynjolfsson and Hitt 1996, Brynjolfsson, Rock, and Syverson 2017, Decker et al. 2017). The world then entered a turbulent new decade in 2020, which began with the emergence of a pandemic. As a public health response, governments across the world have imposed lockdown policies involving extensive social distancing measures. Such measures are, by nature, extremely disruptive to day-to-day life and business activities, and they have taken a heavy toll. As part of a comprehensive plan to support the economy under strain, various governments have put forth substantive fiscal stimuli. For example, the United Kingdom swiftly unveiled a £330 billion ($450 billion) bailout package to support businesses and workers, which amounted to over 15 percent of national GDP. Similarly, the Trump administration in the United States issued an emergency stimulus package of $6 trillion to help American families and struggling industries, such as airlines. In April 2020 the European Union (EU) likewise launched a bailout fund of €240 billion for the health systems and €100 to finance wages. A further €500 billion recovery loan was approved in May. These funds were the result of agreements between all EU member states. Reaching a rapid consensus on such a scale is testament to the urgency of the situation.

These measures have helped to prevent immediate economic collapse but have drastically increased the ratio of national debt to GDP, with negative implications for the future. Excessively high ratios can shake investor confidence and draw resources for national development away to servicing the debt. Moreover, studies have highlighted the negative implications of the high debt to GDP ratio; for example, Forges Davanzati and Giange (2020) suggested that high debt to GDP, coupled with liberal labor market regimes, have reduced long-term employment growth and labor quality. The liberalization and internationalization of financial markets, as well as higher income inequality, may have caused governments to favor high levels of debt to GDP (Azzimonti, De Francisco, and Quadrini 2014), which may be especially vulnerable to the unplanned sudden increase in debt. Figure 1 plots the time path of debt to GDP ratio of several major developed economies just before the onset of the pandemic. The same general pattern may be observed for other countries, with advanced economies in the G20 expected to exceed 120 percent of debt to GDP, significantly higher than G20 emerging economies, which may exceed 60 percent. In this paper, we propose that the high debt to GDP ratio can be reduced to manageable levels by focusing on business model innovation via the adoption digital technologies in order to increase productivity and hence stimulate economic growth, which a recent empirical study has demonstrated regarding total factor productivity (Wannakrairoj and Velu 2020).

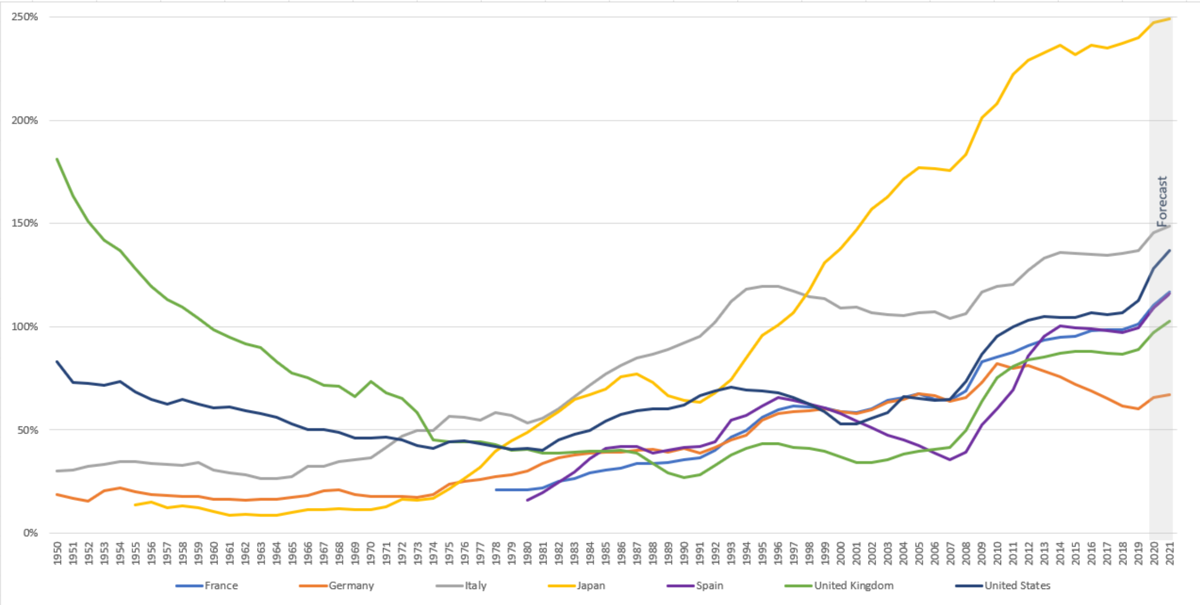

FIGURE 1. PUBLIC DEBT TO GDP RATIOS OF SEVERAL MAJOR ADVANCED ECONOMIES 1950–2020

Source: Financial Times (15 June 2020)

Various studies have discussed the optimal level of public debt (Barro 1979; Aiyagari and McGrattan 1998, Ostry, Ghosh and Espinoza, 2015). However, the 2008 financial crisis had resulted in an episode of debt hikes bringing renewed interest in the topic. Reinhart and Rogoff (2011) hypothesized this to be part of a debt cycle that could last for decades, beginning with household indebtedness, followed by a banking crisis, and, in turn, a sovereign debt crisis, leading ultimately to massive public borrowing and a wave of defaults. Not all economists, however, appeared too concerned. Blanchard (2019), for example, believes that, as long as the rate of GDP growth exceeds the interest rate, even very high debt levels may be sustainable, but not one that grows eternally, which might trigger a credit crisis. Governments of major economies are considered “safe” by investors who are prepared to lend at low interest rates. However, there are at least two problems with this view. First, it presupposes that the interest rate will remain low indefinitely. After the pandemic there may be strong inflationary pressure as consumer demand rebounds, which, in turn, may force an increase in interest rates at a time when economic growth may be sluggish. Second, investor confidence in even the largest and most stable economies, including the US, could also be shaken by this once-in-a-century “black-swan” shock. Smaller economies already ravaged by previous economic crises, such as Greece, are likely to face even higher rate hikes. Boskin (2020) provided an alternative view to Blanchard (2019)’s position, reiterating conventional arguments against high debt to GDP, such as higher future taxation, the crowding out of private investment and challenges to the financial system. As a proponent of Modern Monetary Theory, Kelton (2020) goes even further to suggest that the government can always meet its debt obligation by “printing” money, and that the only constraint to debt is the quantity of real resources in the economy. Deficit, in this regard, is merely the transfer of investment from private to public agents, with the latter often able to yield greater social marginal return – contrary to the mainstream neoclassical assumptions that have guided policy since at least the 1980s. Although there are views that subscribe to the more optimistic belief that high government debt is less problematic, we focus on the school of thought that there is a need to reduce the government debt to GDP ratio to more manageable levels following the pandemic.

The methods available to address the debt burden situation, which have been tried from time to time throughout history, can be broadly grouped into the following five categories. First, the government can default – and face the economic consequences. In practice, however, the cost in terms of loss of confidence associated with a default usually outweighs the value of the debt in the long term. Second, the government can allow or purposely engineer inflation through monetary policies. Inflation is de facto a wealth transfer from lender to borrower (the government). This is also likely to damage confidence. Third, there is financial repression, whereby interest rates are artificially suppressed (Reinhart and Rogoff 2011, Becker and Ivashina 2018). Similar to high inflation, financial repression represents a wealth transfer from creditors to borrowers. These kinds of wealth transfer may increase inequality if the burden of the higher inflation or low interest rates falls disproportionately to the lower income population that might be investing in government bonds or low interest bearing assets through pension funds or life insurance products. Moreover, interest rates are already at historic lows in many countries, with little room for manoeuvre. Fourth, governments can run a budget surplus via higher taxes and/or reduce expenditure. However, not only is this not politically feasible in many cases, but austerity during an economic downturn may exacerbate and prolong the negative cycle. This leaves the fifth and final strategy as the only solution that does not have significant negative consequences – GDP growth.[3]

As a result of the extent of the challenge, however, it is likely that all of the above five methods will be used in combination. Cochrane (2019) recently proposed the application of asset pricing theory to further our understanding of national debt. Using variance decomposition, Cochrane (2019) showed that expectations of future budget surplus and real interest rates determine almost the entirety of the (market) value of debt to GDP ratio, while the contribution of economic growth is negligible. Sustainable surpluses, however, usually require good overall economic health, while low real interest rates may be achieved via high inflation and/or financial repression. This novel perspective therefore provides a framework with which to view the various debt to GDP-related issues holistically, and how they can be effectively addressed. Nonetheless, we focus on economic growth as the optimal solution, not denying the complementary benefits and rationale of the other approaches, particularly in the short term.

In this article we argue that emerging next-generation digital technologies such as artificial intelligence (AI), 5G connectivity, cloud computing, and 3D printing, when combined with new

[3] Ostry, Ghosh and Espinoza (2015) argued that even when the government is in a position to pay off the debt the cost of doing so via distortionary taxation would likely outweigh the benefits. Instead they suggest that the debt should be permitted to decline organically, falling as a proportion to GDP.

business applications, will be vital for bringing about this much-needed economic growth, lowering the debt to GDP ratio as a result. Discussions about productivity growth often implicitly assume the absolute necessity of ground-breaking technological change; yet insufficient attention is given to how smarter deployment, more effective management, and changes in business models can significantly improve productivity under existing technological capabilities. Moreover, such organizational changes may even accelerate the pace of technological development. We make the case that, historically, productivity improvement associated with new technologies has often been accompanied by business model innovation (BMI). We then use the framework of Santos, Spector, and Van der Heyden (2015) to articulate and categorize the various types of BMI that new digital technologies may enable. Taking the US as a reference, if the combination of new digital technology and BMI result in productivity growth increasing from the current projected 1 percent per annum to 3.5 percent, which is comparable to various high growth periods throughout history, this would reduce the debt to GDP ratio to the pre-pandemic level of around 80 percent by 2045 (CBO 2016). By contrast, the ratio will significantly expand if productivity growth remains at 1 percent. Finally, we discuss policy recommendations for governments to encourage BMI in the next wave of digital revolution in order to spur productivity and help repay the high government debt following the pandemic.

II. HISTORICAL CONTEXT

Historically, whenever national debt to GDP ratios have significantly exceeded 100 percent, it was often a harbinger of a looming economic crisis. There were two well-documented instances when the ratio was lowered without substantial economic disruption – Britain following the Napoleonic War, and the United States after the Second World War. In both cases there was rapid post-crisis economic growth (Strauss 1942, Yarrow 2008). In the case of Britain, the government debt had reached £850 million at the close of the Napoleonic War, when GDP was only around £400 million. The war expenses were largely financed by such national debt held by aristocratic parliamentarians, and the interest charges alone amounted to £32 million per annum. Taxation was increased to pay off the debt, which was a de facto wealth transfer from the working population to the rich. The resultant concentration of wealth, however, led to the financing of many capital-intensive projects and technological applications, which spurred the Industrial Revolution. Productivity increased as a result. A similar view was expressed by Barba (2020), who believed that public debt redemption gradually eliminated unproductive farmlands that had to be sold for debt payment. For the US, the military technological investments began to be commercialized after the war. There was a systematic effort to form linkages between academic and industrial research, which contributed to productivity gains (Rosenberg and Nelson 1994), effectively converting them into knowledge public goods. In addition, the growth of factor inputs also contributed to the growing economy, perhaps even more so than productivity improvements (Jorgenson 1988). Economic growth, whether through productivity or factor input increases, enlarged the tax base to eventually allow a budget surplus, while the debt diminished as a proportion of GDP. The situation after the end of the pandemic will be different in two crucial ways. First, prior to the war, productivity growth was already on an upward trajectory in both Britain and the US, but the opposite was the case before the pandemic. Second, largescale movement of labor and capital will be more uncertain in the post-pandemic world. Thus, in order to lower the debt to GDP ratio, a fundamental restructuring of the economy to break the pre-pandemic downward pattern will be necessary, and this must be achieved without counting on a significant increase in factor input.

Unlike other economic crises, such as that in 2008, which disproportionally affected demand, the pandemic also severely affects the supply side. This is because it is now evident that the shock induced by the pandemic is not temporary but will have a long-lasting effect on firms and employment, permanently eroding the economy's productive capacity. Therefore, simply boosting aggregate demand using conventional fiscal measures would be insufficient to revive economic activity, leading only to inflation. This means that raising aggregate supply by rebuilding the economy's supply capacity is the key to economic recovery.

Economic growth models have established that long-run high-quality economic growth ultimately depends on technological progress, while endogenous growth theories later proposed that economies that actively invest in R&D will grow faster than those that do not (see Romer 1994). The effect of R&D on economic growth appears to be strongly supported by empirical evidence (Park 1995, Rouvinen 2002, Hall, Mairesse, and Mohnen 2010, Atkinson 2019). Atkinson (2019) presented the case for government support for R&D in the US, particularly at the federal level. Should R&D increase to 3.4 percent of US GDP from the current 1.4 percent, an additional net revenue of $1.2 trillion per annum by 2039 would be realized as a result of higher productivity. This would, in turn, halve the projected annual deficit from $2.6 trillion to $1.3 trillion, and the projected debt to GDP ratio would fall from 176 to 92 percent – in other words, the R&D funding more than pays for itself. Aside from a quantitative increase in funding, Atkinson (2019) suggested that productivity should be explicitly factored into R&D funding allocation decisions. Seven fields of industrial activities were identified where R&D is particularly likely to translate into productivity gains – robotics, autonomous transportation systems, artificial intelligence, additive manufacturing, material sciences, microelectronics, and advanced computing and life sciences.

While technology-led R&D may be the underlying driver of economic growth, attributing all productivity gains to it greatly simplifies the story. The "technological progress" of economic models never exclusively meant technological advancement but simply embodied all output growth in excess of observable input – known as total factor productivity (TFP). This encompasses efficiency gains not only from technology-led R&D but also organizational improvements and better synergy between technology and business processes. New technology may not initially function in sync with the firm's business model, resulting in limited productivity (Chesbrough 2007). Major productivity improvement is often attained only when organizational restructuring facilitates the complementarity between technological and intangible capital (Brynjolfsson, Rock, and Syverson 2017). Higher productivity is achieved by gaining not necessarily more resources but more efficient combinations of existing available resources (Mithas et al. 2012). Field (1987), for example, deemed the emergence of modern business enterprises (MBE) in the late nineteenth century as comparable in kind to technological advancement. MBEs are characterized by the divorce of ownership and control, which created incentives for professional managers to improve efficiency in order to justify their high salaries. This led to dramatic increases in TFP, which Field (2009) argued was the main driver of economic growth, and not capital deepening, as conventionally believed. Similarly, Mohun (2009) hypothesized that some reorganization of labor processes, such as more effectively bringing work to labor, was responsible for an increase in labor productivity in the US in 1982–97 without capital deepening.

Some scholars hold a less optimistic view with respect to future technological development. Gordon (2000), for example, argued that the rapid proliferation of personal computers and internet usage from 1995 onwards, while impressive, falls far short of the truly life-changing inventions from the early twentieth century, such as washing machines, electric lighting, and automobiles. Gordon (2000) thus concluded that the productivity impact of this "new economy" would be limited and not sustainable – an observation that could potentially be supported by the recent slowdown in productivity, although other explanations such as the impact of the financial crisis are equally plausible. Bloom et al. (2020) argued that the returns to knowledge production may be diminishing. This is especially true for a well-defined technical process. Less sanguine views such as these, tend to focus on the technological constraints to productivity growth. By contrast, we argue that, even without further technological breakthroughs, there is scope to apply existing technologies in radically new ways. The combinatory possibilities are endless, and there is no evidence that productivity growth from better technological deployment is exhausted. Decker et al. (2017) argued that a lack of entrepreneurship and business dynamism may be a major reason for declining productivity. BMI therefore will be critical and may help by encouraging a variety of new solutions for customers, businesses and government via the creation of different niches of technological applications, offsetting the productivity slowdown.

III. BUSINESS MODEL INNOVATION AND TECHNOLOGY

A business model summarizes the architecture of a business and defines the organization's value proposition and its approach to value creation, value capture, and the value network (4Vs) brought about by an ecosystem of firms, that is, the components of the 4Vs and their inter-relationship (Zott and Amit 2007, Casadesus-Masanell and Ricart 2010, Zott et al. 2011, Velu 2017). A business model can also be understood in terms of *content, structure,* and *governance* (Casadesus-Masanell and Ricart 2010). Content outlines which activities are part of the business model. Structure is about how these activities are linked to one another. Meanwhile, governance relates to who can make decisions about them. Context, structure, and governance encompass internal, as well as external, partners in affecting productivity (Serpa and Krishnan 2018). BMI thus provides an avenue of productivity improvement by altering any of the components and/or the relationship between them. The onset of new technology often provides the impetus for BMI. Firms that fail to adapt their business models during technological transitions lose out to new players and end up as low-productivity firms (Morris, Schindehutte, and Allen 2005), while those that seized the opportunity via BMI are able to establish a competitive edge over rivals to become high-productivity firms (Markides and Charitou 2004).

Today , several digital technologies and critical infrastructures such as AI, cloud computing, and 5G are developing rapidly and may transform the economic landscape on which firms compete. The transformation may be compared to several general purpose technologies (GPT) in the past, including steam and electricity (David 1990, Velu 2020). Electric motors were introduced around 1879 to replace steam engines, yet productivity initially declined slightly up to 1920, before beginning to rise rapidly (David 1990). The rapid productivity growth in US manufacturing may be attributed to new organizations and business models that only emerged in the 1920s. The new business models involved putting multiple electric motors where they are needed and leasing them from external firms with specialist support services. This enabled productivity growth through lower energy consumption, improved production flows, and greater resilience.

A more contemporary example of GPT can be seen in the development of information communications technology (ICT). Despite becoming ubiquitous since the 1970s, Solow famously stated that "You can see the computer age everywhere but in the productivity statistics" (see Triplett 1999), which summarized the productivity paradox of a "Discrepancy between measures of investment in information technology and measures of output at the national level." David and Wright (2003) pointed out that ICT deployment and its economic contribution in the 1980s were comparable to that of electricity in the early twentieth century (David 1990). Although computers were becoming commonplace, its functionality was often limited. The underlying computing technology was the mainframe, which was downsized as machines for specific applications, such as task-specific word-processing systems. Such devices, however, did not meet user needs well because of the lock-in effects of proprietary software. In the mid-1980s personal computers facilitated the growth of more generic software that was more customizable and could be upgraded, thus quickly displacing dedicated computers. The generic software also bundled together various new capabilities such as "desktop publishing" (typeset quality documents), which greatly enhanced individuals' ability to express ideas and improved the quality and quantity of their communications. Similarly, Steinmueller (2000) implied that the information processing, storage, and retrieving capabilities of ICT were not sufficiently cost-effective in the early years compared to conventional methods of paper bookkeeping and secretarial input, without the host of complementary usage and practices that emerged later. In the mid-1990s the long-expected productivity growth began to materialize, which may have been, at least in part, caused by the proliferation of personal computers as a general platform for a range of new organizational activities and business models. This "paradox" and its apparent end are shown below in Table 1.

TABLE 1. GROWTH RATES OF MAJOR WORLD ECONOMIES IN DIFFERENT PERIODS

	US Real GDP per Person	**US Real GDP per Hour Worked**	**EU-15 Real GDP per Person**	**Eu-15 Real GDP per Hour Worked**
1950–73	2.5	2.6	4.0	4.9
1973–95	1.7	1.3	1.9	2.5
1995–2007	2.2	2.2	2.0	1.5
2007–16	0.4	0.9	-0.1	0.4

2014–23	-	-	1.0	0.8
2016–26	1.0	1.4	-	-

Source: Havik et al. (2014); CBO (2016); Crafts (2018); the Conference Board (2016)

By 2005, however, productivity growth again decelerated. Kleinknecht (2020) believed that an overly liberalized labor market with low job security and frequent labor turnover may have discouraged the incremental accumulation of firm-specific knowledge that is key to productivity-enhancing technological innovations. This may also stifle effective BMI, as a detailed understanding of the firm's anatomy is often required. However, low labor turnover may instead create structural rigidity, which becomes resistant to difficult but necessary organizational changes. Technologically oriented BMI is therefore impacted by the state of the labor market, which should be sufficiently balanced to encourage both cumulative firm-specific knowledge and rapidly flowing people and ideas to provide "fresh blood." The innovation in different types of industry, including BMI, may demand a different mix of these two mechanisms.

IV. BUSINESS MODEL INNOVATION TYPOLOGY AND PRODUCTIVITY

The productivity boom from the late 1990s onwards may be attributable to the emergence of new business models such as e-businesses, which resulted in effective complementarity between ICT and organizational structure (Zhu 2004, Zhu, Kraemer, and Dedrick 2004, Hsu, Kraemer, and Dunkle 2006). We apply the framework developed by Santos, Spector, and Van der Heyden (2015) to analyze the role of BMI in enhancing the productivity gains through ICT. Santos, Spector, and Van der Heyden (2015) classified BMI into several *typologies*, including *reactivating*, *relinking*, *repartitioning,* and *relocating*. These typologies are summarized in Table 2. *Reactivation* refers to either adding a new business activity or removing it from the current business model. *Relinking* means an alteration involving either changing the transaction governance among business activities or the interdependence among organizational units in the current business model. *Repartitioning* is an alteration that moves the organizational unit performing an activity, which may involve insourcing or outsourcing, or alternatively moving the activity from one organizational unit to another within the same company. *Relocating* involves the shift in the same business activity to another country. This may involve offshoring where the activities are moved abroad, or onshoring where they are brought back to the country where the company is based. We now provide examples of how these archetypes of business model innovation helped to improve productivity, with further examples in Table 2.

TABLE 2. TYPOLOGY OF BUSINESS MODEL INNOVATION (SANTOS, SPECTOR, AND VAN DER HEYDEN 2015), WITH EXAMPLES OF PRODUCTIVITY INCREASE ENABLED BY ICT

Classification	Type	What Changes	Example
Reactivation – altering the set of activities performed by the company	Adding	The activity set of a company's business model by adding	Clayton, Sadun, and Farooqui (2005) – ICT enabled BMI to add online sales channel via e-commerce. The business model evolved, whereby websites initially served primarily as a source of information before becoming an online channel. Sampled firms increased exports by 500% at one point.
	Removing	The activity set of a company's business model by removing	Prabhu, Arora, and Mishra (2018) – telecommunication firms move away from their conventional call and text capabilities in pursuit of multimedia service provisions such as broadband.
Relinking – altering the linkages between activities	Regoverning	The governance of transactions between market, hierarchy, and hybrid	Olszak 2019 – ICT innovator takes responsibility for introducing a comprehensive value chain, while other firms then join to create the value chain, providing specific products and services. Rambus and Dolby are examples of firms using this approach.
	Resequencing	The order in which organizational units perform activities, *or* the interdependence among organizational units between pooled, sequential, and reciprocal	Clougherty et al. (2020) – firms bring together their old and new capabilities to enhance existing operations, often tapping into complementary knowledge from other industries. Redeployment and recombination are strategies to address the threat of declining productivity.
Repartitioning – altering the boundaries of the focal company by moving an organizational unit across business boundaries	Insourcing/outsourcing	The location of an organizational unit moves from outside to within the company, or from within to outside the company	Siegel and Griliches (1992) – computer investment is associated with the outsourcing of in-firm services. Examples include repair, maintenance, legal, accounting, and other business services. This helps firms to specialize in other activities so they do not have to develop such expertise in-house, which may be difficult for many small firms. Firms' decisions to insource, by contrast, are governed more by desire to control the process, often for strategic reasons (Drauz 2014).
	Reassigning	The location of an organizational unit moves from one unit to another within the company	Sartor (2006) – creating an international purchasing office (IPO) is becoming a solution frequently adopted by Western firms operating in China to manage the different social, cultural, and legal context.
Relocating – altering the	Offshoring	The geographical location of an organizational unit	Tomiura (2007) – some Japanese manufacturing firms have moved their

boundaries of the focal company by moving an organizational unit across business boundaries		from within to outside the company's home country to a foreign country	services abroad; firms active in foreign direct investment (FDI) in multiple globalization modes tend to be more productive firms.
	Onshoring	The geographical location of an organizational unit from a foreign country activity unit into the home country	Moe and Hanssen (2012) – Scandinavian software development firms initially offshored to lower costs. However, they onshored because of low quality, insufficient domain knowledge, high turnover, and a lack of motivation among external developers.

i. Reactivation

Potok and Vouk (1997) simulated object-oriented software development, which is deemed a technical solution with high productivity potential to satisfy the demands in an industry of ever-reducing product life-cycle times. The results, however, showed that in order to achieve high productivity, the current business model requires the addition of management practices that give firms a wider range of control. On the other hand, standard practices that emphasize timely delivery guarantee may need to be removed. This is because such methods suffer from the common drawbacks in software development, such as the "deadline effect," where the project quality becomes compromised as a result of excessive resources being devoted to meeting deliverables within a pre-specified timeframe. Tulu, Hilton, and Horan (2006) examined this relationship in the health-care industry. ICT added to the existing business model the customer value proposition of fast, efficient, and independent evaluation of disability criteria. This replaced and thus removed the practice of manually assessing disability status and whether individuals qualify for compensation, which involves numerous confusing definitions since different compensation programs use their own definitions. By using ICT disability assessment, the process became automated, significantly reducing labor cost and wastage in processing inefficient claims.

ii. Relinking

Dewan and Kraemer (1998) alluded to Dell (computers) altering its manufacturing model through regoverning its relations with customers. ICT facilitated the connection with customers to enable direct sales and build-to-order production of computers for specific customer segments. This model had been so successful that in the 1990s it was emulated by all major PC companies. Dell's revenue had grown at an average annual rate of 55 percent during the late 1990s. Papp (1999) conducted an econometric study of the financial performance of 500 US firms over a five-year period. Productivity gains were achieved whenever ICT became aligned with corporate strategy and actively played a part in its formation. Zolnowski et al. (2013) studied the relationship in the service industry. "Servitization" has been a major BMI trend, where, rather than engaging in one-off sales of durable products, firms partake more in providing the services associated with the products on-demand, as well as supplying sophisticated after-sales services to improve the overall experience. Instead of the value being embedded in the products for sale (value-in-exchange), the business model logic has increasingly shifted to one where value is generated as customers use the products (value-in-use) (Vargo and Lusch 2008, Svensson and Gronroos 2008). This concept is particularly relevant in education, where customers are intricately involved in the value creation process (Prahalad and Ramaswamy 2004, Gustafsson et al. 2011). A productivity increase in education is therefore characterized by a high degree of value co-creation, where services are designed and delivered in close collaboration between providers and customers. ICT can facilitate this process by increasing the ease of communication and data sharing, often observed in transformation to online books, which are conductive to provider–customer interactions.

iii. Repartitioning

The decision of firms to insource or outsource is often governed by the laws of transaction cost economics. Williamson (1985) hypothesized that whether a particular activity should be insourced or outsourced depends on asset specificity, frequency of firm–supplier interaction, uncertainty, and the necessity to maintain in-house control. ICT reduces the cost of communication, which increases firm–supplier interaction and certainty, as suppliers can be better monitored to reduce opportunism. ICT therefore provides the means for firms to take advantage of outsourcing, increasing productivity through cost reduction, and economies of scale. Product quality may also improve as a result of selecting specialized suppliers for parts, resulting in economies of scope (Yu 2012). Even ICT services themselves are frequently outsourced because of the need for specialized equipment and knowledge. Chang and Gurbaxani (2012) found that firms that outsourced their ICT services derived productivity improvements compared to those that did not. In manufacturing, the trend has been to outsource processes that are not considered "core functions." These tend to be low-value and labor-intensive activities (Broedner, Kinkel and Lay 2009). Qu, Oh, and Pinsonneault (2010) studied the reverse situation of insourcing ICT services. Compared to outsourcing, insourcing choices may be driven more by strategic concerns. The study found that the insourcing of ICT services is more effective than outsourcing for developing ICT-enabled business processes, which subsequently lead to superior productivity. While outsourcing ICT may enable firms to reduce costs, market differentiation rather than cost competition may be the firm's strategy. Seen in this light, ICT services may increasingly be viewed as a core function because of the unique role they play as a source of competitive advantage. Therefore, outsourcing may not match the firm's strategy compared to the development of complementarity between ICT and other technology with business processes (Lee, Chu, and Tseng 2011, Stucki and Wochner 2019). Insourcing also appears to be a recent trend in manufacturing (Stentoft, Mikkelsen, and Johnsen. 2015).

iv. Relocating

Similar to repartitioning, ICT facilitates productivity growth of relocating by reducing the cost of communications. Offshoring/onshoring decisions have led to productivity increases, depending on the context of specific firms (Olsen 2006). ICT therefore provides the *option* for firms to offshore, should they deem it consistent with their business strategy. The literature regarding offshoring is focused heavily on the manufacturing context driven by cost considerations, where non-core components are produced in developing countries with lower labor and regulatory costs (Porter 1994, Marin 2006). Although, strictly speaking, offshoring refers only to the relocation of an activity to a foreign destination, which could still be within the same company, such as a foreign subsidiary, in practice offshoring is frequently associated with foreign outsourcing (Quelin and Duhamel 2003), even though the two are different concepts. Similarly, onshoring is associated with insourcing. Like insourcing, there has been a trend for onshoring or backshoring in recent years. Kinkel and Maloca (2009), for example, found that between one-sixth to a quarter of German companies sampled, which had previously offshored, have now backshored. There are fewer studies on the benefits of onshoring, yet these benefits can be inferred from studies on offshoring and their associated risks (Drauz 2014). Several reasons have influenced firms' decisions to onshore. First, there is the failure to meet expected cost savings, such as rising wages in previously low-cost regions (Shih 2013). Second, there are high monitoring costs (Kinkel 2012). These may include hidden costs and risks such as lower product quality, supply chain disruptions, and difficulties caused by the recent rise in protectionist sentiments around the world. The recent pandemic, of course, is the elephant in the room in terms of global supply chain risk. These reasons mean that the total cost of offshoring may not be any less than onshoring (Platts and Song 2010). Third, the benefits of offshoring may have declined. Modern manufacturing, with a greater focus on quality, standardization, and customization, derives less benefit from low-cost labor. The rise in robotic automation has been a major factor in manufacturing firms deciding to onshore (Slaby 2012, De Backer et al. 2018). Fourth, excessive reliance on low-cost locations may result in a loss of intellectual capital, and over time the capacity to innovate (Steinle and Schiele 2008). Therefore, firms that offshore certain activities do so because they are able to lower costs and thus increase productivity, while firms that onshore do so to increase productivity by avoiding the risks associated with offshoring.

The experience of ICT and its productivity impact via BMI may provide a precursor to what is to come with the new generation of digital technology. Wannakrairoj and Velu (2020) developed a novel approach to measuring BMI and found that it had a positive impact on productivity growth in UK firms between 2003 and 2017. According to Van Ark (2016), the introduction of GPTs which drastically impact society can be divided into the installation and deployment phases. The installation phase is characterized by initial usage among only first mover firms which may gain competitive edge but the benefits are not consistently large across firms. The deployment phase on the other hand is when widespread benefits are felt across the entire economy. The transition between the installation and deployment phases involve a lot of experimentation in the application of new technologies. BMI can therefore help smooth the transition from the installation to deployment phases by exploring novel ways for implementing new technologies quickly in order to locate profitable avenues for development and encourage widespread adoption.

V. BUSINESS MODEL INNOVATION AND PRODUCTIVITY FROM NEXT-GENERATION DIGITAL TECHNOLOGIES

Digital technologies such as Distributed Ledger Technology (DLT), Additive Manufacturing (AM), 5G connectivity, cloud computing and the application of Artificial Intelligence (AI) and Machine Learning (ML) are beginning to find industrial applications as GPTs, but they are still at a relatively nascent stage of development. The business model implications of these technologies have often been envisaged in the concept of Industry 4.0 or the Fourth Industrial Revolution, where all digital units are interconnected and continuously rely on data in real time. It seems reasonable to anticipate that the newer digital technologies need to be accompanied by BMI before they are able to unleash major productivity boosts that are transformative for the economy.

Brynjolfsson, Rock, and Syverson (2018) have described the productivity phenomenon often accompanying the introduction of new technologies, which they termed the J-curve effect – productivity declines initially before rising again. The declining portion may last a long time, and it is not inconceivable that in the absence of intervention it will take decades for the new digital technologies to impact productivity noticeably. With the short- to medium-term economic climate looking bleak, compounded by heavy national debt, it will be highly problematic if productivity uptick takes anywhere near this length of time. BMI may be able to significantly shorten the timescale between a technology's initial conception to its final transformative effect on society and economy.

In order to illustrate our thesis that the new digital technologies require complementary BMI, we examine an example of spare-parts replacement in household durable goods in the context of additive manufacturing. Major advances in 3D printing are beginning to have an impact on industries in producing and replacing parts, but they have yet to be accompanied by complementary BMI, without which the full productivity potential across the industry will remain untapped (Bogers, Hadar, and Bilberg 2016, Kurpjuweit et al. 2019, Klockner et al. 2020).

Managers often adopt new technologies for process improvements with less emphasis on redesigning the entire system to function integrally, suffering from the “piecemeal syndrome” (Skinner 1987, Velu 2020). If, for example, a component in a washing machine were to become faulty beyond repair, the consumer might have to contact the retailer, which then contacts the manufacturer, asking for that specific component to be sent out from its storehouse located elsewhere. The entire process may take several weeks to be completed, causing substantial inconvenience for the consumer during the wait. Now, in an integrated additive manufacturing network of the future, the appliance may be embedded with sensors capable of diagnosing the machine’s integrity, notifying failure or upcoming potential failure of parts. This information can be connected with manufacturers in real time, which then share data files with a third-party 3D printing firm in the local vicinity to punctually produce, deliver, and install the parts. Once the work has been completed, payment can be automatically deducted via a smart contract. The entire network can be managed using DLT, which permits the accurate recording of the contracts and various procedures, ensuring security via encryption. The inter-connectivity between different parties requires advanced digital connectivity infrastructure such as 5G, which also enables the functioning of cloud computing to provide the computational resources needed by AI algorithms for the purpose of predictive maintenance, and to optimize various processes. The above example illustrates how a range of digital technologies are brought into play via the additive manufacturing network. In order to take advantage of the opportunities, firms in the relevant sectors need to collectively seek BMI around the digital technologies. The typologies of Santos, Spector, and Van der Heyden (2015) can once again be employed to categorize the types of BMI that are likely to emerge.

Regarding *reactivation*, the equipment manufacturing may remove the production of parts using conventional subtractive manufacturing technology and replace it with production using 3D printing. This lowers the cost and risk of holding inventories and specialized equipment, while enabling greater customization flexibility. AI and big data can improve the prediction of maintenance needs, reducing servicing requirements. AI will be an important technology, which is used to gradually refine the prevailing technical issues of 3D printing that still need to be ironed out, such as low surface quality and slow fabrication speed. The design process itself may also undergo fundamental shifts, with old and obsolete activities associated with standard product designs removed and replaced with new design concepts. For example, current product designs are highly labor-intensive. With ever-shortening product life cycles, this approach will be less cost-effective. Instead, much of the product design functions can now be automated using AI (Verganti, Vendraminelli, and Iansiti. 2020). With access to vast data, AI systems are even able to design products for individuals, rather than designs that target entire populations.

In terms of *relinking*, businesses can form closer contractual arrangements with manufacturers located near customers, which will impact supplier relations. For example, the original equipment manufacturer of the washing machine could be paid to license its intellectual property to third-party 3D printing firms located near to customers, which are able to print and replace the spare parts faster. We may see the re-emergence of just-in-time production, since a business model based on close and long-term collaboration with localized suppliers will be necessary to ensure the delivery of products and maintenance in a timely fashion. Unlike just-in-time production, however, additive manufacturing would eliminate the need to hold inventory altogether and not merely transfer this task to the supplier. The network relationship can be established via DLT, which enables various firms at different stages of the supply chain to become connected and to interact in a relatively secure environment.

Smart contracts can be generated without the firm necessarily having a formal contractual agreement with localized suppliers or plants.

The kind of linkages that may evolve as a result of additive manufacturing has the potential to radically alter existing organizational relationships. For example, decentralized and less hierarchical arrangements will become possible, which would allow greater flexibility for all parties involved. The hierarchical arrangements that constitute firms designed to internalize the costs of agents behaving opportunistically are likely to become less necessary. This would, in turn, have implications for the boundaries and definitions of the focal firm. Klockner et al. (2020) have shown that different types of organization, including academia, software, semiconductor, and law firms, are exploring the potential for collaborative interactions to address the multifaceted challenges involved in additive manufacturing. Therefore, under the influence of additive manufacturing, organizations from diversely different fields may be brought together to partake in coordinated efforts, which are more likely to occur across, than within, industries. This may create value chain networks, which are more industrially diverse than previously, and which would, in turn, give rise to economies of scope in place of economies of scale, as the main source of productivity gain.

Regarding *repartitioning*, there is substantial room to increase productivity via outsourcing, which has not been utilized. The bulk of the valuation in 3D printing innovation lies in computer aided design (CAD) files, which give precise printing instructions. The current intellectual property (IP) protection framework is inadequate to deal with problems relating to the sharing of CAD files (Kurfess and Cass 2014). This is a hindrance to the widespread use of 3D printing, as firms may be reluctant to outsource 3D printing. DLT has the potential to alleviate many of the barriers, giving rise to several outsourcing BMIs. First, firms that produce 3D printing CADs can more easily commercialize their CAP IP portfolio. A particular design may be licensed to third parties to print a specified amount for a specified time period, with little risk of IP theft or misuse. Second, firms can also outsource designs that they do not themselves use but which nonetheless have commercial value for other firms. In this way, productivity is improved via reduced wastage. With greater coordination between firms, additional manufacturing capacity may also be outsourced to other firms. This not only generates extra revenue but also allows productive resources to be more efficiently allocated within the industry and economy. Third, because of the greater degree of customization, there may be more scope for greater customer involvement in additive manufacturing (Halassi, Semeijn, and Kiratli 2019). Firms have therefore outsourced a part of the value creation process to customers, who have become value co-creators.

In terms of *relocation*, organizational units and third-party firms with 3D printing capabilities should be located near to localized customers. This is the opposite of the offshoring model that dominated manufacturing for several decades. Compared with a globally outsourced manufacturing chain, localized additive manufacturing is likely to significantly reduce labor input, eroding the cost advantages of many overseas locations with low labor costs. Other technologies such as industrial robots also facilitate automation, negating labor cost differentials. Providing a localized service or customization will become increasingly central to competitiveness. In addition, the pandemic has raised questions regarding the need for a more resilient global supply chain. Against this backdrop, firms that seek to increase their supply security may build more localized networks, a hedge against sudden shocks that seem to have become more prevalent.

VI. GOVERNMENT POLICY RESPONSE

In light of these potential for BMI, the government should consider various policy initiatives to accelerate its development, which is critical in order to escape the debt trap. First, the government should provide subsidies and grants, not only for these new digital technologies but also for their business applications. The current tax regime already provides rebates for firms that invest in cutting-edge new technologies. This, however, may only be sufficient to induce firms to introduce piecemeal changes, without fundamentally altering the underlying processes. There is little incentive for firms to go the extra mile and implement corresponding organizational changes. The government should therefore consider subsidizing firms that have, or have plans to implement, organizational and business model changes designed specifically to complement their technological assets. The tax scheme can go even further and subsidize these changes that take place *between* firms. Firms can jointly apply for finance if they alter their current interactions with other firms in response to their technologies. This will encourage intra- and inter-industry firm coordination, achieving complementary BMI, not just within but across entire industries. Transformative business models may increasingly depend not on the institutional changes of individual firms but on that between diverse firms with different strengths, brought together by common interest, which the tax scheme can encourage. This can be taken even further to encourage collaboration with universities and higher research institutions.

Second, the government can also permit tax rebates if firms are able to demonstrate productivity improvements via independent audits. Although firms clearly have an incentive to improve productivity, the incentive may not be sufficiently strong for two reasons. First, productivity, as conventionally defined via accounting principles, is rarely measured directly by firms and does not drive their day-to-day decisions. Second, firms are ultimately motivated by profit, and profitability can be achieved not only via productivity improvement but also through appropriating a greater proportion of value from competitors and consumers. Arguably, the latter approach is often easier to achieve than productivity increases, aggravated by a lack of competition in many markets. With tax rebates, for example, set to a given proportion of productivity increase, the financial incentives for improving objectively measurable productivity will become stronger. We should note that there are current debates regarding whether existing productivity measures are appropriate (Brynjolfsson and Hitt 1996, Nordhaus 2001); hence, the government should allow a more flexible approach to the definition of productivity used.

Third, the government should provide relevant training. Skills shortages in the scientific, technology, engineering, and mathematics (STEM) areas have been identified as a bottleneck to technological innovation. There may be an equivalent skills deficit relating to the identification and exploitation of BMI opportunities. Hence, the government should provide training in BMI-related skills, centered specifically around transformational opportunities provided by the next generation of digital technologies. For example, the government could encourage firms to measure the digital skills and capabilities of their employees and provide training and subsidies for firms to improve such digital skills capabilities, which could act as the input to encourage business model innovation. The application of ICT and past technologies to various business models may serve as case studies to contextualize the BMI training, so that they are better able to sense opportunities from the new technologies that are analogous to those already in widespread usage. Providing use cases of the benefits of digital technologies and the potential business opportunities would be crucial in promoting BMI, especially among small and medium-sized enterprises. This might involve both network hubs for firms to share best practices, and demonstrators of new digital technologies to showcase the benefits. It is important that such programs help to foster firm-specific skills but at the same time not overly restrict labor turnover to the extent that over time innovation including BMI is impeded because of a lack of people–idea exchanges. The government can subsidize firms to provide more apprenticeship programs fostering firm-specific skills. In addition, it can also provide directly industry-specific training in collaboration with firms in selected industries, such as those identified by Atkinson (2019), which are particularly likely to increase productivity. Industry-specific skills may be a balance between the need for long-term cumulative knowledge and excessive organizational rigidity. This is because they give workers sufficiently specialized skillsets, as well as a degree of mobility between firms within the same industry. Such skills may be underprovided by firms, as it is a de facto public good for the entire industry. During times of technological and organizational transformation, there is always the possibility of unemployment due to technical substitution for labor, which may also occur in this case. It is challenging to fully predict such outcomes but the effects from robotics automation may shed some light. The prevailing consensus is that robots do not reduce labor demand per se but induces structural changes in the labor market, such as raising the demand for high skilled labor at the expense of low skilled labor, or that it is largely the medium skilled labor which is negatively impacted (Autor

2013, Autor and Salomons 2018). The government should be cognizant of these structural shifts and institute appropriate retraining schemes to prevent potential skills mismatch in the workforce.

Fourth, the government can seek to encourage the emergence of common standards across the industrial chain, aiming to encourage greater cross-firm and cross-industry collaboration. The emergence of DLT, for example, has meant the decline of transaction costs, which, according to the Coase Theorem (Coase 1960), implies economic efficiency, provided there are clearly defined property rights. Establishing common standards would be tantamount to building the property rights framework. Existing policy tends to focus on developing technical standards or protocols that facilitate communication between different technology types and platforms, but this needs to be extended to cover the "soft" standards around various business processes. Even the boundary of the firm may become increasingly fuzzy and need to be revisited in order to encourage task-oriented freelance contracting and other modern work arrangements. This should begin with the legal framework being redesigned, which is currently inadequately equipped to address the concerns of emerging technological use, such as file-sharing arrangements in additive manufacturing (Kurfess and Cass 2014). The legal processes, in general, evolve very slowly, and yet the technological and business model changes that they regulate often happen relatively quickly, which can cause the two to become out of sync. Hence, the government can consider adopting a much more nimble legal framework for use exclusively in technological and business-model-related matters, which is less subject to the complicated political checks and balances in conventional law. Such a legal framework must also respond rapidly to any international technical standards that emerge.

TABLE 3. SUMMARY OF POLICY OPTIONS

Policy No.	Current Policy Framework	Issue to Address	Proposed Policy Response	Desired Outcome
1	Financial incentives in place to encourage the adoption of state-of-the-art digital technologies.	Limited incentives for firms to implement the complementary business and organizational processes when implementing digital technologies, or to alter existing	Subsidize firms that engage in BMI in response to technological assets. Subsidize joint ventures between firms that alter inter-firm business interactions due to use	Foster complementarity of digital technology in order to encourage BMI at both the individual firm level and across the entire industry, where the strengths of different

		relationships with related firms.	of digital technologies. Non-profit research institutions such as universities may also partake in joint efforts.	entities complement one another, resulting in economies of scale and scope.
2	Tax regime centered on profitability, factoring in capital gains and depreciation.	Limited incentives to raise measurable productivity from BMI, as the incentives are geared ultimately to profitability.	Allow tax rebates if firms are able to demonstrate productivity improvement as a result of specific measures taken.	Firms will more explicitly try to increase productivity, which will lead them to alter existing business processes and develop new business models, which may be technologically related.
3	Recognition of STEM skills as vital for the economy, especially for technological research. Liberalized labor market with low job security and high rates of labor turnover.	Less attention paid to skills that facilitate BMI. Workers in many industries prioritize generalized skills to maximize overall employability at the expense of acquiring cumulative firm-specific skills, which are often necessary for innovation.	Provide training in BMI-related skills, using new generation of digital technologies as the context. This may involve various demonstrations and networking platforms. Subsidize apprenticeships and the provision of firm-specific training, while directly providing industry-specific training. Factor in potential structural effects on labor market.	Relevant human capital developed to enable more digital-technology-related BMI, which may be especially beneficial to small firms. Reach a balance between encouraging cumulative knowledge without causing excessive organizational rigidity.
4	There are existing technical standards in widespread usage. The current IP regulation is complex and subject to political/legal checks and balances that evolve slowly.	Common standards have yet to emerge across new value chain activities such as distributed manufacturing. The legal infrastructure is unable to keep pace with the issues that arise as a result of rapidly changing technologies.	The development of a more flexible framework for use exclusively in digital-technology and business-model-related matters, which can evolve quickly without the constraints of conventional law. It also needs to be responsive to the decisions of international developments in these areas.	Accelerate the emergence of new value chains and network clusters, such as distributed manufacture, by removing key barriers.

Table 3 summarizes these policy proposals, the issues they address under the current policy framework, and the objectives. All of the above are possibilities that government regulators should consider. However, for quicker and more effective results, there may be a need to use a combination of the above approaches as an integrated policy response. Such an integrated policy will act to enhance each policy package and be mutually complementary. A comprehensively integrated policy involving all, or at least a number, of these elements should be thought through and strategically implemented. Given that such initiatives will be a long-term endeavor, with little, if any, short-term payback, political and social consensus will be crucial. In electoral democracies that are subject to periodic election cycles, cross-party commitment to implementation should be sought. Not only must the work of the current government not be undone by the next, but ideally all successive governments should view them as a matter of priority. This is more likely to be achieved if everyone understands that the policies hold the key to recovery from the pandemic and that the benefits are maximized if there is continuity.

VII. CONCLUSION

We have briefly described the economic and fiscal situation in advanced economies following the pandemic, with the post-pandemic era likely to be one of a (near) unprecedented level of debt to GDP ratio. The only sustainable and sound means of reducing this ratio is via substantial productivity growth. Historically, the introduction of new technologies was characterized by a lack of productivity growth initially. Only when complementarity was established between the new technology and the firm's business processes was major productivity growth realized, and this was achieved via the creation of new business models or BMI. The latest example of this can be seen in the development of ICT as a GPT. BMI in terms of reactivating, relinking, repartitioning, and relocating were facilitated by ICT, which resulted in productivity gains. The next generation of digital technologies is also likely to require BMI prior to major productivity boosts. The Santos, Spector, and Van der Heyden (2015) framework was employed to categorize some of the BMI that may take place, and this is illustrated by the phenomenon of additive manufacturing. We have suggested ways in which the government may encourage some of these developments to assist in the BMI process, which taps into the productivity potential of these technologies. By emphasizing BMI, governments may be able to shorten the time from technological research to commercialization, thereby shortening the negative portion of the productivity J-curve effect. This is now critical, as we may be engaged in a time “race” against the huge debt and their interest payments. The next generation of digital technologies presents new and exciting opportunities, hastening the winds of change toward greater productivity, which may lead to both positive as well as negative social changes, including potential structural unemployment. Therefore, having the appropriate business models will be like putting up the mast of the economic ship, while government policies to encourage the right kinds of BMI will be the rudder.

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