The future of manufacturing industry and its implications for developing countries

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Introduction

Industrialisation has long been synonymous economic progress and structural change away from agriculture and services towards manufacturing was one of central policy recommendations of the early development literature from the 1950's and 1960's.[1] The world economy has changed considerably since then and manufacturing's role has been subject to scrutiny. A vast literature has explored and tested aspects of the 'engine of growth' argument based on manufacturing's potential for productivity growth through innovation, dynamic economies of scale and learning. Whilst manufacturing retains an importance, particularly for low and middle-income economies wishing to raise income levels rapidly, over the last thirty years or so several trends in these economies have become clear (Haraguchi et al 2016).

- The division between manufacturing and services has become blurred with many non-production activities previously done by firms themselves sub-contracted to specialist service providers;
- Other sectors, principally the modern branches of services and to a lesser degree agriculture, have begun to exhibit relatively rapid productivity growth, so that manufacturing is no longer the only source of dynamism;
- In most countries, the employment impact of manufacturing has been weakening with a shift to greater capital intensity in production;[2]

[1] Fred Nixson was an early and distinguished analyst of the role of manufacturing in development and supervised and examined many students on this topic; see for example Kirkpatrick and Nixson (1983) and Kirkpatrick et al (1984).

[2] Globally there has been a slight decline in manufacturing employment, at around 0.9% annually between 1990 and 2018 (UNIDO 2020).

- Progress in manufacturing in the group of developing economies has been very uneven with some seeing positive employment growth and a rising share of manufacturing in GDP and others seeing the reverse, with a tendency towards a concentration of production in China and a few leading economies.[3]

Old debates on the merits of open versus closed-economy strategies from the 1960's and 1970's, have long been superseded by an awareness of the importance of the external market for low and middle-income economies. However, the terms on which such countries should participate in international trade and capital flows remain contested and there remains considerable debate on how far government policy can support and influence industrialisation. Whilst the early development literature assumed such support would be essential, the influence of neoclassical and monetarist thinking in the 1970's led to a rejection by many governments of interventionist solutions. When governments were judged to be 'part of the problem, not the solution', it followed that 'the best industrial policy is to have no industrial policy.' This reluctance to intervene was never based on very firm economics and over the last 20 years or so in both academic and policy circles there has been a significant revival of interest in using policy to affect resource allocation.[4]

There of course remain many disagreements, for example on how far such a policy should utilise market-based incentives and how far it should rely on direct controls, how far it should aim to provide general support and how far it should be selective and in identifying areas to support how far it should depart from current specialism based on comparative advantage. A widely held view of 'modern industrial policy' is that it must differ from earlier versions of policy, for example as practiced successfully in East Asia in the 1970's and 1980's, but less successfully elsewhere, where the government sets a priority list of activities and supports these with a variety of measures including subsidised credit, controls or tariffs on competing imports, and access to infrastructure. Contrary to this top-down version, the current emphasis is on a participatory and experimental approach, where priorities for support emerge from an ongoing dialogue between the government and the private sector and where the means of providing support must vary with circumstances, rather

[3] The term here covers the UN definition of emerging, developing and least developed economies, excluding China. For the country coverage see UNIDO (2020). Over the period 1990-2018 China's share in global manufacturing value-added increased very substantially from 3% to 25%, while that of the developing countries was stable at around 20%.

[4] See the chapters in Oqubay et al (2020) for reviews of different aspects of industrial policy.

than being based on a standard predetermined list.[5] Industrial policy in this sense is also not focussed exclusively on manufacturing but on all 'modern sector' activity, for example in services and parts of agriculture, where there is the potential for dynamism and productivity growth.

Industrial policy must adapt to the stage of development of an economy. Weiss (2015) distinguished between 'early', 'middle' and 'late' industrial policy, with the broad focus of policy changing between these. At the early stage the key focus is on developing simple manufacturing and resources processing; at the middle stage on production upgrading and the local adaptation of foreign technology; and at the late stage on science-based innovation at the technology frontier. Whilst income level is a crude proxy for governance, administrative and technological capability, as a broad generalisation income per capita a simple way of distinguishing where the different stages of policy apply. Hence, again very approximately, early-stage policy can apply to low and at least some lower-middle-income economies, and mid stage policy to upper middle-income and late stage to high income.[6]

At each of the three stages identified here, industrial policy, like all other policies will need to adapt to future changes in the global economy, driven by ongoing 'mega trends' (EU 2020, UNIDO 2022). This chapter discusses three such trends and considers their implications for the design and application of industrial policy, particularly in the context of low and-middle income economies (LMIC).

- The fragmentation of production based around production value-chains
- Technological breakthroughs leading to production based on digital technology, or 'smart production'
- Moves towards the greening of industrial development

Spread of Global Value Chains (GVCs) or Global Production Networks (GPNs)

[5] The idea of 'product discovery' as set out originally in Hausmann and Rodrik (2003) provides the theoretical basis for this approach. Aiginger and Rodrik (2020) give a recent restatement of this view of industrial policy. Using examples from Ethiopia, Weiss and Seric (2020) discusses how a problem tree approach can be applied to select the policy instruments to address bottlenecks holding back growth in specific activities.

[6] This is the World Bank classification based on Gross National Income per capita in current dollars; until July 2022 the definitions are Low Income below $1046, Lower-Middle Income $1046 - $4095, Upper Middle Income $4096-$12,695, High above $12,695; see World Bank Blogs, New World Bank Country Classification by Income Level 2021-22, July 1 2021, www.worldbank.org. Given the wide range of income in the middle - income category, in terms of policy the classification of some middle-income economies can be ambiguous, with some having a policy environment closer to early-stage policy, whilst in others it may be closer to mid-stage policy. There can of course also be differences between sectors in the same economy. For simplicity this ambiguity is ignored in the discussion

Since the 1980's low-cost traditional manufactured exports, like garments, toys and processed foods provided an effective form of job creation in the more successful exporter economies. More recently there has been an increasing tendency for production to fragment in the sense that the share of trade in intermediate goods that feed into other goods has risen substantially as firms relocate elements of the production process to other countries. The import of intermediate goods was part of the export promotion policy recommended to poorer countries in the 1970's as a development strategy, but its acceleration in the 1990's was facilitated by a fall in transport costs and the spread of communications technology leading to the development supply chains stretching across national borders, in what have been termed GVCs or GPNs.[7]

There is still expected to be scope for this type of export growth, but technical change and any slowing in world trade, combined with disruptions such as those experienced during the Covid 19 pandemic, are likely to limit its effectiveness as mechanism for employment creation. This has led some observers to stress the need for greater focus on the domestic market and an expansion of this market through regional trade agreements and market integration.[8] This may be appropriate for larger economies and those with closely integrated regional neighbours, but is not an option for others. Hence the issue of how far firms from low and middle-income countries can and should integrate into these supply chains remains highly relevant.

For international lead firms the key motive for production fragmentation was the relocation of aspects of their production process to low wage economies. The standard interpretation of this fragmentation is that relatively mature technology was transferred to producers in developing countries, while the high value-added segments of the value-chain – such as research and development, product design and marketing could be retained in the home base of the lead firm.

The advantage of this process for poorer countries was that it enabled their firms to obtain a foothold in employment creating activities and an entry into global export markets. However, since production had to meet international quality standards backward linkages to other domestic producers who might

[7] Timmer and Pahl (2021, figure 15.1) show the domestic value-added content in world manufacturing exports falling from 0.87 in 1970 to below 0.7 in the early 2010s, although there is evidence of a slight reversal since then (World Bank (2017). The share of GVCs in world trade rose significantly from 1990, but fell slightly 2010-2015 (World Bank 2020: figure 0.1)

[8] Rodrik (2018) points to growth of the domestic market in several African countries as a driver of recent growth.

supply inputs to the local production in the value-chain were often difficult to establish and the controls imposed by the lead firm on the use of their technology, meant that local experimentation and adaptation was difficult. Hence the widely cited statements that the spread of value-chains has made industrialisation 'easier but less profound' and that trade in goods has been replaced by 'trade in tasks' as producers specialise in specific aspects of the supply chain (Baldwin 2011).

The evidence suggests that membership of these supply chains has had a positive impact on productivity growth, but not on employment (Pahl and Timmer 2020). Whilst in manufacturing in general the relation between growth in output and employment appears to be weakening it has been argued that there is a particular cause for concern in the case of global value chains as the increasingly more sophisticated technology transferred by lead firms is biased against unskilled labour and in favour of skilled and semi-skilled workers, with the implication that in future low wages competitiveness will become less important as an attraction for lead firms (Rodrik 2018).

In terms of the implications of GVCs for industrial policy different perspectives on industrial policy not surprisingly give different policy recommendations for low and lower-middle-income economies. The neoclassical position, as exemplified in World Bank (2020) sees greater liberalisation as the response to sluggish growth in GVCs.[9] This involves reductions in any remaining import barriers, not just import tariffs, but the associated trade costs covering insurance and transport, as well as administrative barriers. Liberalisation of services to allow foreign suppliers to compete in domestic markets is seen as particularly helpful in supporting domestic firms in a chain, given the increasing service content in some manufactures. However, even from this perspective there is a recognised need to go beyond this market-based approach to use more 'proactive' policies, rationalised as a response to 'market failures.'

Three policy areas are highlighted (World Bank 2020, chapter7)

- Supplier linkage programmes to support local firms with a view to establishing them as input suppliers in GVCs
- Development of workforce and managerial skills and capabilities
- Strengthening of national systems of innovation through public-private collaboration.

[9] Weiss (2020) has a discussion of neoclassical versions of industrial policy. Several other chapters in Oqubay et al (2020) discuss heterodox approaches.

More ‘developmental’ or heterodox perspectives on industrial policy would agree with these as priority areas, although there would be disagreement on the degree of emphasis given to and support for these measures, relative to market reforms. If independent successful producers are to emerge this literature stresses the need to develop capabilities in production and technology to allow firms to upgrade either their processes or products within GVCs. Ultimately the aim must be to develop national designs and brands, as has been possible in parts of East Asia (Chang and Andreoni, 2020).

Firms can be integrated into value-chains as wholly or partly owned affiliates of lead firms or as independent producers operating under a contractual arrangement. Policies that promote linkages to GVCs imply a targeting of specialised production niches rather than the establishment of vertically integrated domestic industries, as for example under old-style import substitution. How far upgrading within GVCs is possible, given the dominant position of lead firms, in terms of technology, finance and marketing is a key question. For foreign-owned affiliates the difficulties experienced by hosts governments in shaping their behaviour, for example in encouraging the use of nationally produced inputs or modifying and adapting technology are well known and pre-date the widespread emergence of GVCs in the 1990’s. It is only economies with very large and attractive domestic markets, like China, which are in a strong position to enforce joint ventures which give local partners access to technology.[10]

For nationally-owned contracting firms, the standard argument is that with the spread of GVCs the power balance has shifted from governments to firms, so that the only realistic goal of policy is to strengthen the position of domestic suppliers within GVCs controlled by international firms.[11] This will involve facilitating access by domestic firms to imported intermediate inputs, supporting them in negotiating contracts with lead firms, including access to technology, and generally assisting a move into higher value tasks within a GVC, or to higher value chains (Milberg et al 2014). Encouragement of international supplier firms to locate in a host economy to serve both local suppliers in a chain and to export inputs to the lead firm has also emerged as a

[10] Lee (2022) shows how technological catch-up in China differs across sectors varying the nature of the technology and policy towards the sector. Apart from obtaining technology from joint ventures, the other key routes of acquisition are identified as university-private sector collaboration and mergers and acquisitions with foreign firms.

[11] Chang and Andreoni (2020) argue that domestic firms should seek looser links with foreign buyers or suppliers rather than more formal contractual relations in a GVC to avoid firms being locked into relatively low value segments of a value chain. This sort of judgement is likely to be case-specific, however, since much will depend on the functioning of a GVC and the terms on offer.

strategy, on the grounds that lead firms are attracted to a host economy by the presence of their regular suppliers and national firms can benefit from access to internationally competitive inputs (Gereffi 2015). However, upgrading of either production processes or products within GVCs requires more than access to international goods and services and high standard infrastructure, but support for training, public-private collaboration in technology experimentation and development and the encouragement of backward linkages with networks of domestic suppliers to the contracting firm.

In terms of attracting lead firms there is a fairly widespread recognition that traditional incentive policies to encourage foreign firms to set up part of a GVC, for example offering lengthy tax holidays or access to subsidised power or factory space, have proved relatively ineffective, in comparison with measures like access to high standard infrastructure, a skilled or trainable labour force and a stable contractual environment.[12]

Once firms are part of GVCs some of the more conventional aspects of industrial policy may be less relevant. For example, use of import tariffs and exchange rate adjustments as means of supporting domestic manufacturing are much less effective where firms are part of a larger GVC. Import tariffs to encourage domestic production of inputs raise costs for GVC lead firms and duty-free access to imported inputs is seen as a necessary condition for attracting such firms. It is for this reason the EPZs, which allow free trade in parts and components, are so common. Similarly, adjustment of the exchange rate to set a level low enough to make local manufacturing cost competitive on global markets has much lower incentive effect where imports are a high part of production cost, and so their costs rise in local currency terms if the exchange rate is devalued.

The key issue remains how best to support national firms either as suppliers of inputs to GVCs or to break into export markets as independent producers and ultimately to develop their own brands in the way that successful East Asian firms have done. The agenda set out in World Bank (2020) is clearly a starting point but as discussed below needs to be expanded on the basis of the ongoing trends in technology and government objectives on climate change.

New Technologies

In recent years there has been much discussion of new technological developments that, it has been suggested, are profound enough to constitute

[12] Most surveys of firms place tax incentives fairly low on the list of reasons for investing; see for example, World Bank (2020, Box 7.1)

a Fourth Industrial Revolution (Schwab, 2016). Following from earlier technological breakthroughs associated with the application of steam power, electricity and computing, respectively, it is suggested comes a fourth wave of change based on the application of digital technologies to production that create new forms of production, such as the 'internet of things,'[13] and new products, such as electric cars. This is in addition to their application to retailing, patterns of working and transmission of information.

This 'advanced' or 'smart' manufacturing is said to offer the advantage of both higher productivity and new markets, and the ability to meet precise customer specifications rapidly, if necessary, in small batches.[14] Some aspects, particularly the use of industrial robots, stem from the earlier technology associated with the information communication technology (ICT) revolution. In addition, the spread of new forms of production, especially the ultimate stage of a 'smart factory' driven by computerisation and automation is, as yet, very limited, even in higher income countries.[15] However, the expectation is that in the coming decades this form of production will dominate in many sectors with the spread of processes like automation, robotics and 3-D printing. If so, what are the implications for industrial policy?

A point made frequently is that in this new environment it makes sense to think of supporting technologies rather than specific types of output like garments or computers. If new technologies feed into a range of different sectors catching-up in terms of new technologies makes more sense than supporting particular sectors, at least for upper-middle income economies, like Brazil or Mexico.[16] This type of support will involve both direct funding and tax credits for R and D, however, evidence from OECD countries suggests that the use of tax credits is more successful for the development side of R and D, than for basic research, which is likely to require direct funding (OECD 2021).

[13] This has been defined as 'the next iteration of the internet, where information and data are no longer predominantly generated and processed by humans… but by interconnected smart objects … that engage in machine-to-machine communication' (UNIDO (2020: xviii)

[14] "The smart manufacturing system connects the product design, analytics, manufacturing process, stocks and supply chain system, product customisation, real time machining units, product delivery system and the end customers through the use of cloud computing, which (*has*) made on-demand manufacturing, product customisation … more efficient" Phuyal et al (2020).

[15] UNIDO (2020) goes into detail on the application of advanced digital production (ADP) technologies to manufacturing. It reports that 91% of patents for ADP technologies are held in ten countries and its surveys reveal a very limited application in production in low and middle-income economies, with limited capability to use them effectively.

[16] This is a route than has been followed in the EU, for example, where in recent years little support has been sector-specific, mostly going either to regional policy or technology development (Landesmann and Stollinger 2020). EU (2020) stresses the key role of technology and sets out policy support measures for European firms.

However, funding alone is unlikely to be enough. The technical complexity of this advanced manufacturing at the technology frontier has major implications for both public and private firm policies. In the early stages of technology life cycles at the frontier the overhead cost and knowledge required is likely to be beyond the resources of even large global firms. This necessitates partnerships and collaboration between private firms, universities and research institutes, typically with government funding.[17] Critical is the development of what has been described as infra-technology to provide the technology platform to allow the commercial application of new technology (Tassey 2014). This technical infrastructure provides the basis for standard setting, measurement, testing and quality control. Public-private joint provision of such infrastructure is now an integral part of industrial policy where governments seek to support activities at the technology frontier.

The employment consequences of this trend have been a major cause for concern. As technology becomes increasingly more sophisticated so does the need for local skills to use it effectively. Hence the traditional focus on education and training as a central feature of industrial policy assumes an even greater relevance in this new production environment. This is heightened by the widely held view, noted earlier, that the latest wave of technical change will see the substitution of unskilled labour by skilled labour, which is more likely to be complementary with the new technologies (Rodrik 2018).

As yet the evidence on the links between the introduction of technical change based on robots and AI and total employment is unclear, with a range of different effects found across countries, although there is evidence that manufacturing jobs and those based on routinised and low and middle skill activities jobs most at risk. As yet few studies focus on low and middle-income economies, but one cross country analysis distinguishing between developed and emerging economies finds a stronger negative effect on employment in the latter (Barbieri et al 2018). The implication is that this is picking up a tendency to replace low wage jobs in emerging economies by automated production in developed economies. Hence the need for policy to focus on both job creation and raising skill levels in middle and low-income countries.

In addition to a skill bias in technical change, it has also been argued that there are other factors inherent in recent technical change which change the nature

[17] Tassey (2014: 37) cites as evidence the case of IBM and in its work on nano-electronics, which moved from relying on its own research departments to collaboration, with amongst others the University of Albany, Intel and Texas Instruments, with funding from the government of New York and the US Federal government. The key role of public support for technology development in the US, most recently through the Innovation and Competition Act is stressed by Coyne and Muhtar (2021).

of GVCs and which weaken the position of low-income economies within these. Two new trends have been identified – re-establishment of the link between production and innovation and a reduction in the scale of production for technically advanced high-end manufactures (Bailey and de Propris 2020:487). The link between production and innovation is supported by the emergence of successful 'regional innovation clusters' where the benefits of agglomeration are derived from local research consortia, education infrastructure, a talented labour pool and the emergence of locally-based suppliers (Tassey 2014: 39). The implication is that for sophisticated manufactures aimed at niche markets the old generalisation that production is the stage of the value chain which creates a low value added per unit of output, and which it is in the interests of lead firms to transfer to low wage economies, no longer holds. This changes the incentives for lead firms, since if production experience is essential for successful innovation, this is a strong argument for bringing at least some production back to the home economy in a process of 'reshoring.' As yet these are interesting hypotheses and how far they are generalizable across the less technologically sophisticated branches of manufacturing remains to be seen, but if true, they will weaken the spread of GVCs.[18]

Appropriate skills will need to be combined with an infrastructure, such as high-speed fibre networks, that will allow access to efficient digital technologies. At present such networks as far from the norm in even in higher income countries and some low and middle-income countries still struggle in maintaining reliable power supplies.[19] This is the background to the so-called digital divide whereby digital access is distributed very unevenly between firms in an individual country and even more so between countries. A particular concern is access to digital technologies amongst smaller firms, which in some countries have been important generators of employment in the past.

Firms further away from the technology frontier, that is the vast majority of firms in low and lower-middle-income countries, will be working with analogue rather than digital production techniques and support here is likely to require information on access to technology imports that can be applied competitively at the stage of production of the firms, and where appropriate incentives to attract GVC lead firms to the economy. Industrial policy in a development

[18] As yet there is relatively little evidence of reshoring. The survey of European firms reported in UNIDO (2020:21) finds that it is not widespread, that where it does occur from developing or emerging economies that it is primarily due to the need for flexibility in logistics and that it is more frequent in firms and sectors using advanced digital technologies.

[19] As of December 2019, in the whole of OECD the average high speed fibre coverage was only 28% of total subscriptions (OECD 2021:102).

context will need to acknowledge that the digital transformation in many firms will inevitably be gradual and cannot proceed beyond the pace set by the available physical infrastructure and human resources within those economies. In the short term it is unlikely that digital technologies will play a major role, which means that more traditional production techniques will remain important. If relatively low wage costs allow competitive production of exports using more traditional or analogue technologies this need not be a major concern.

In higher income economies it is expected that use of the new 'smart' technologies will become increasingly common in the future as firms will need its introduction to be competitive. Here it is clear policy must aim to equip workers with the education and training necessary to use the new technologies, to establish an adequate infrastructure base and to support firms wishing to access the new technologies. In lower-income economies further from the technology frontier, the key dilemma is how far technological leapfrogging, moving directly from traditional to frontier technology, makes sense. Whilst firms would need to identify the scope for this process, in terms of both demand and supply capacity, for the more substantial leaps some form of state support in collaborative research and development would be needed.[20] The evidence is that countries (like Taiwan, Korea and more recently China) that have managed to catch-up with high income economies, in the sense of capturing major shares of global markets in sophisticated products, have all needed to undertake leapfrogging in some sectors (Lee, 2022). As part of industrial policy this type of support cannot be ruled out but the potential benefits would need to be assessed carefully against the risks of failure and countries need a significant domestic technological capability and institutional support base before such a strategy would make sense. There is a parallel with discussions that saw infant industry protection in the 1960's as an investment, with short-term costs to consumers followed by potential long-term benefits in productivity growth and knowledge spill-overs (Baldwin 1969). The key difference is that infant industry protection usually involved a well-established technology, whereas leapfrogging by definition does not. This makes successful outcomes highly uncertain and means that makes standard benefit-cost analysis very difficult to apply (Weiss 2018).

[20] Lee (2022) distinguishes between leapfrogging in terms of adopting the most up to date technology ('stage-skipping') and creating a new indigenous technology ('path creating'), with the latter involving by far the biggest leap and therefore requiring the greatest state support.

Green Development

The climate change emergency has emerged as a major preoccupation for industrial policy over the last 15 years or so. It is well known that manufacturing is a major emitter of green house gases and although the emission intensity of production has been reduced in recent years the growth of production has led to a continued rise in total emissions, particularly in middle-income economies.[21] Many of the issues the green version of industrial policy needs to address are shared by earlier approaches, however some aspects are distinctive (Altenberg and Rodrik 2017). Several of the arguments used to justify any form of industrial policy – such as the need to internalise external effects, to provide co-ordination between independent actors and to support innovative research – apply even more strongly in the environmental area.

In large polluter economies the role of policy should be clear. Governments need to act urgently, given the evidence on 'tipping points' in the climate emergency, whereby beyond a certain point damaging change becomes irreversible. Critical decisions on means of reducing carbon emissions need to be taken urgently and the early, apparently high, estimates of global damage up to 20% of GDP in Stern (2007), if long-run climate effects are not addressed, no longer appear extreme. The systemic nature of the changes required to address climate change issues means that innovation, energy provision and natural resource management must be linked. This is consistent with the 'mission-oriented' approach to industrial policy, which suggests that aspects of policy should be designed to serve a key long-run goal, like sustainability and meeting the SDGs (Mazzacuto and Kattel 2020).

The precise details of how such a policy would operate are not always clear, but in general it implies setting stringent overall long-run environmental targets, such as net zero carbon emissions by a certain date, whilst backing this up with clear sector specific targets. These targets become constraints which the investment and other support measures must work to.[22] This implies a combination of imposing environmental taxes or a removal of any environmental subsidies, if the policy is to be based on price incentives, or

[21] Reflecting the pace of industrialisation, particularly in East Asia and China, total CO2 emissions from upper middle-income economies rose from around 4 million tonnes in 1995 to over 9 million in 2010, and in lower middle-income economies from around 1 million tonnes to just over 2 million; UNIDO (2017) figure 4.1.

[22] Mazzacuto and Kattel (2020) give as an example the mission target of achieving SDG 15 on cleaner oceans. This involves political agreement, a specific target (such as globally reducing the level of plastic in the sea by say 75% of the 2015 level), innovation for example in developing plastic substitutes and in recycling, and specific projects to apply these innovations and to facilitate the detection and removal of plastic. The role of environmental industrial policy is to initiate or support the necessary innovations and to ensure these are translated into projects.

alternatively command measures to meet minimum emission or other standards or to cease use of technologies, or forms of production by a target date.[23] In addition, from this perspective a phasing -out of existing polluting activities, becomes as important as a phase-in of greener alternatives. This may require short-term support in terms of worker retraining and financial and technical support for enterprise restructuring. A possible funding source for these measures would be the revenue raised by environmental taxation.

Within this framework governments must operate industrial policy, essentially as a tool to meet environmental goals. Support for both basic and applied research must focus on ways of designing and producing goods with low emissions content. The move to smart manufacturing discussed above helps in this process, but digital technologies and internet-based production systems, still require energy and if energy supply systems are not based renewables there will be a weaker effect in emissions reduction.[24] Hence low carbon infrastructure investment become essential.

Governments need to ease the transition to a more sustainable development path by providing as much certainty as possible to producers, for example in setting meaningful long-run targets (for example emission standards for auto production) or offering guarantees for sustainable technologies (for example purchase agreements for wind-based energy), and as much clarity to consumers as possible through effective product labelling. They also need to ensure co-ordination, so that opportunities are not lost because firms act independently. Obvious examples are that firms will not invest in electric vehicles, without some way of ensuring that there will be an adequate electric charging infrastructure and a competitive supply of batteries available. Similarly renewable energy investment must be integrated into an overall energy plan so that it can be absorbed in the grid.

Internalizing externalities, so that firms re rewarded for benefits they create for others, but penalised for costs they impose, is a central rationale for industrial policy and environmental effects are the classic example of an externality referred to in economic textbooks. In relation to technology choice this means ensuring that the price system is reformed so that environmental costs are included in the prices facing producers. A similar point applies at the stage of product disposal, since waste re-processing can be encouraged by raising charges for waste disposal, which are very low in many countries.

[23] Mandatory requirements on firms in China to meet energy efficiency targets are an example of this command approach (Never and Kemp 2017: 93).

[24] For example, in China the early electric cars made there were just as polluting as petrol cars because they were powered by carbon-intensive electricity and used lead acid batteries (Altenberg et al 2017).

Attempting to ensure polluters pay some or all of the costs they impose on others is a key element of any green industrial policy, but one which can be difficult to implement. The two standard approaches are alternatively a 'cap and trade' system whereby a limit to emissions is set for a given period and the right to generate pollution is auctioned and subsequently traded in carbon market, or a system of environmental taxes on either the use of non-renewable resources or polluting activities. Both are subject to lobbying and in practice most auction systems have seen very unambitious caps and hence relatively low charges for rights to pollute.[25]

Taxes, whilst easier to administer, are also subject to lobbying pressure to keep down costs to producers. In addition, in practice it can be difficult to establish a level of tax appropriate for the environmental damage caused by an activity as the academic literature contains a wide range of estimates for this damage. None the less, however it is achieved, it remains important that in some way the price system can reflect environmental damage, so that the decisions of producers and consumers can be influenced in a more sustainable direction.[26] Environmental charges imposed in an individual country will put its producers at a disadvantage, if competitors do not face similar charges. The option of imposing some form of carbon border tax on imports can be complex to implement and risks creating trade disputes. Hence this is an obvious area for global harmonisation and an international dialogue on how economic policy co-operation can support goals on prevention of further climate damage. There is major need for global co-operation in sharing information on new technologies and in funding the adjustment costs in low and lower-middle income economies. However, it is also possible that market competition between countries in terms of subsidising environmental technologies can lead to spill-over benefits to the rest of the world, if the subsequent technology breakthroughs can be copied, allowing the establishment of suppliers in other countries.[27]

[25] For most of the period since its inception in 2006 the carbon price in the EU Emissions Trading System (ETS) was below Euro 20/tonne of carbon, well below most estimates of the associated global damage for the same period (Tol 2009). As of January 2022, it rose to over Eur 90/tonne, principally because gas shortages in the global energy market creating an expansion of coal-based power and a strong demand for carbon offsets (see S. Boehm 'There's a massive bubble in the price of carbon – and yet it won't bring emissions down any faster' Yahoo News January 19, 2022.

[26] Schlegelmilch et al (2017) discuss the merits of the alternatives and recommend a tax-based system for low and middle-income economies.

[27] Altenberg and Rodrik (2017:15) suggest this happened with solar panel production. Germany subsidised domestic solar panel production, leading to a major technological breakthrough, and the early establishment of an industry. This was then adopted in China, where the large-scale of production led to a major fall in costs leading to global low-cost supplies and a major boost for renewable energy.

Where there is a political will to address the problem the 'mission' approach to policy is directly relevant for high polluter economies. In the short-term rich polluter economies can afford to reset priorities away from economic growth, although if model projections are to be believed continuation of current trends in the long-run would create sufficient climate shocks to significantly lower living standards. Hence in the long-run there is no trade-off. For poorer economies currently contributing very low levels of emissions, there is a real trade-off in the next few decades between growth and the environment, as these countries need higher growth to raise living standards, whilst currently contributing very little to global emissions.[28]

Poorer countries suffer a double inequity in that they have not been responsible for the vast majority of global pollution, yet the effects of global warming in changes to land use and sea levels will have the most severe effect on their citizens. It seems both sensible on grounds of equity and practical impact, in the short-term for the main efforts at pollution control to be focussed on high income- high polluter economies. This allows industrial policy in the low polluter low and lower-middle income economies to adopt a more traditional emphasis on fostering new and competitive industries, at least in the short-term, but with adjustment for environmental concerns. Introducing a focus on sustainability, means a key concern will be finding new market opportunities as part of the emphasis on 'build back better.' Support for solar panel production and electric cars are key examples of new products encouraged by governments, with a view to firms acquiring first mover advantages, whilst at the same time having positive environmental effects.[29]

This version of policy would mean new investment with growth potential is supported, whilst government should aim to ensure that the price system reflects environmental costs, even if only approximately, so that damaging subsidies, for example for energy products, are removed and where feasible environmental taxes are imposed. These economies will be technology-importers, so firms operating there have the opportunity draw on technical advances elsewhere that can reduce environmental damage. This is not the same as a 'mission-oriented' approach, relevant in a high-income context, where growth is subordinate to meeting specific environmental targets. Rather

[28] A clear illustration is that in a year the average person in the UK contributes 200 times the polluting emissions of the average person in the Democratic Republic of Congo, whilst the average person in the US contributes nearly 600 times. Similarly in terms of minor global impact, if 48 countries in Africa tripled their energy consumption using natural gas this would add only 1% to global emissions (Guardian 'West accused of 'climate hypocrisy' as emissions dwarf those of poor countries', January 28th, 2022.

[29] Mazzacuto (2013) discusses support for solar panel production in China and Altenburg et al (2017) discuss that for electric vehicles.

it requires that industrial policy continues to support the development of competitive activities to raise productivity and income in the economy, whilst aiming to avoid the most serious environmental consequences. Any new activity will have some positive emissions effect, and it is neither reasonable nor feasible to expect low and lower-middle income economies to offset all of these by lower emissions elsewhere in the economy.

Conclusions

A brief survey such as this cannot do justice to these very broad issues. However, the basic message is that industrial policy in its 'modern' version is highly relevant for today's high-income economies. Here the primary focus of policy should be on innovation and the development of environmentally sustainable technologies, combine with support for restructuring as older technologies and products are phased out. Given the complexity and high overhead costs associate with research into smart manufacturing technologies a state-private sector partnership is now recognised as essential.

For low income and lower-middle income economies that are technology importers not innovators, there is scope for industrial policy to play a more traditional role. In the poorest countries, including much of sub-Saharan Africa, providing effective and functioning physical infrastructure aimed at supporting new activities, can be the single most critical element (Weiss and Seric, 2020). Measures like technical training, credit provision and public procurement can support infrastructure initiatives. Fiscal incentives like tax holidays and trade measures, including import tariffs, can have a role if used selectively and for a limited time, but are unlikely to be as central to policy as in earlier decades, in large part because of country commitments under regional and global trading agreements. The case of upper middle-income economies is likely to be a mix of these approaches, since in a few sectors their firms may be operating at or close to the technology frontier. Here continued innovation will be important to develop international competitiveness.[30]

The three mega trends discussed here raise different challenges for policy. In terms of GPNs the issue for governments of lower and lower middle-income economies is how best to support national firms in a chain. In most cases the key short-run issue is how best can governments encourage linkages between lead firms and domestic suppliers to maximise national benefits. The direct

[30] UNIDO (2020) reports the results of a survey on the progress of Brazilian firms in adopting advanced digital technology. No firms were fully digitalised but some progress had been made.

measure of local content requirements, forcing lead firms to sub-contract a certain proportion of the cost of production to domestic suppliers, worked relatively effectively in the past in countries like China and Mexico, chiefly because lead firms wanted a presence in the domestic market. However, it is now contrary to WTO regulations that prohibit discrimination in favour of domestic activities over foreign trade, and for most low and middle-income economies is not a viable option. This means that support for linkages has to be by persuasion based on the competitiveness of local suppliers. Policy support for this will need to be a familiar mix of credit or direct investment, education and training and infrastructure provision.

Lead firms come from high income and in some cases upper-middle income economies and the issue for governments of these countries is how far they should encourage re-shoring of these firms, for example by tax incentives. It can be argued this should be largely a decision for firms based on their assessment of costs. However, the emergence of 'regional innovation clusters' suggest that having innovation based within an economy can generate significant agglomeration externalities, in the form of knowledge spill-overs and that having production located domestically can help innovation. Hence, in theory, there is a case from a national point of view to support returning production activities to a national economy.

The new technology associated with smart manufacturing poses challenges for governments in high income economies as it is widely argued that in future competitiveness will be driven by its use. This supports the innovation aspect of policy. For lower and lower-middle income countries in the short-run, whilst 'leapfrogging' by importing the new technology cannot be ruled out, it is likely to be feasible only for a minority of firms, with an adequate skill base and technological infrastructure. The key question is how far the spread of smart manufacturing technology will weaken the incentive for global firms to locate production in low wage locations leading to a weakening of GVCs. If the skill-bias argument on technical change proves correct the expectation is that this effect will be picked up in at least some sectors, although its strength is likely to vary depending on the initial labour-intensity of the technology. In some activities the part of the production process in a low wage location may be unaffected by the use of smart technology in other parts of the chain.

Finally, sustainability concerns need to be incorporated in industrial policy. Responsibility for addressing negative impacts on the environment, and in particular climate change, needs to rest with the high polluter economies, who are in the high-income and middle-income categories. For this reason, the

suggestion here is that ‘mission-oriented’ industrial policy whereby industrial goals are constrained by environmental targets is relevant for the key polluters, which of course will include some of the larger upper middle-income economies, like China, Brazil, India and Mexico, whose size and relative industrial dynamism, means they are becoming significant polluters. For most low and middle-income countries, in general environmental policy should be improved, particularly by reforming the tax system to incorporate environmental costs and benefits in market prices. However, as conventionally, in the short term policy should focus on supporting activities with potential for competitiveness and productivity growth.

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