

Special Feature B

The Impact Of Technological Progress On Inflation: A Review

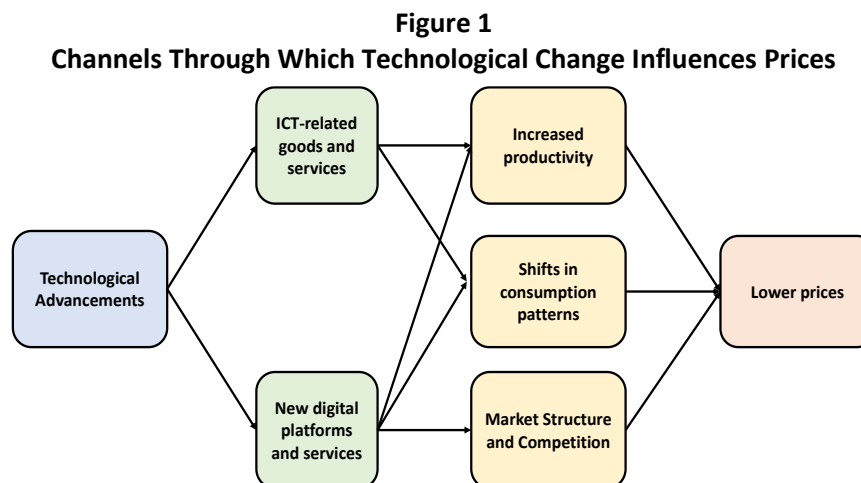
Introduction

Inflationary pressures in both advanced and developing economies have been relatively muted since the Global Financial Crisis despite firming economic growth and rising resource utilisation. This ‘missing inflation’ puzzle has generated much debate on the possible contributing factors, including shifts in price dynamics driven by technological advances.

This Special Feature reviews the literature and empirical research, and attempts to identify the channels through which technological

progress can influence the price-setting behaviour of firms. It also draws out the implications for inflation dynamics, making reference to Singapore where applicable.

There are two main channels through which technology can affect price dynamics. (Figure 1) In the first instance, advances in technology can directly lower the prices of ICT-related goods and services. Second, technological change can indirectly influence prices by changing consumer behaviour, market structure and competition.



The Direct Channel

Advances in technology have contributed directly to a decline in the prices of ICT-related goods and services over time. Part of this is due to increased productivity as a result of continuous technological innovation, as embodied in, for example, the oft-cited Moore’s Law.¹ At the same time, it reflects relative price adjustments as

consumption patterns shift in response to advances in technology. For example, consumers are increasingly switching from cable television services to subscription-based online streaming services such as Netflix. New products that subsume a range of functions performed by other goods or replace older goods completely have

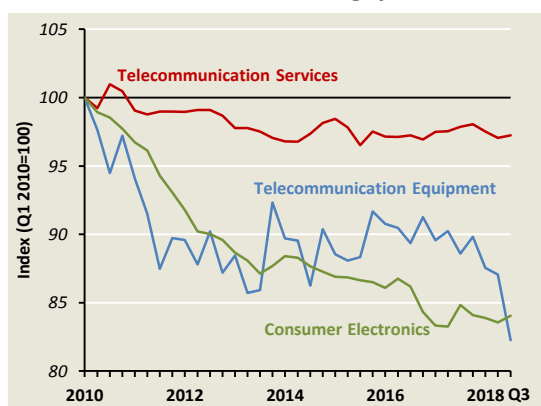
¹ Moore’s Law refers to the empirical observation that computer processing speeds roughly double each year while costs halve.

also emerged. For example, Varian (2016) notes that the smartphone is a substitute for a range of goods, including cameras, GPS devices and personal computers. To the extent that tech cycles outpace the incorporation of new products and services into price statistics, reduced demand for ‘transition’ goods and services that are being replaced may imply a downward bias in price measures for such products, potentially suppressing inflation in the aggregate (Mersch, 2017; Goolsbee and Klenow, 2018).

In line with broader price developments elsewhere, the prices of ICT-related goods and services in Singapore have trended down over the years.² (Charts 1a and 1b) For example, the prices

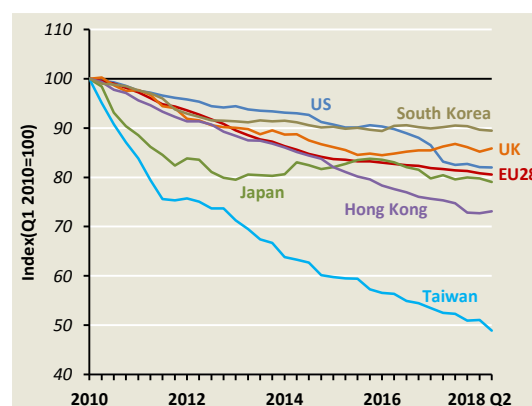
of consumer electronics, which include audio-visual equipment (photographic goods, television sets etc.) and information processing equipment (personal computers, software and other computer peripherals) have fallen by 16% since 2010. The cost of telecommunication equipment saw a similar decline, reflecting advances in computing power and production technologies underpinning the ‘smartphone revolution’ that has made access to smartphones ubiquitous since the launch of the first Apple iPhone in 2007. Prices of telecommunication services have been likewise driven down by expansions in network capacity and competition among service providers as Singapore progressively deregulated its telecommunications sector.

Chart 1a
Price Indices of ICT-related Goods and Services in Singapore



Source: EPG, MAS estimates

Chart 1b
Comparison of Price Indices of ICT-related Goods and Services Across Countries



Source: National statistical agencies, Haver Analytics and EPG, MAS estimates

The Indirect Channel

The second, indirect channel through which technology can affect inflation is through its influence on consumer behaviour, market structure and competition. This is most evident in the emergence of online platforms that have altered consumer behaviour, such as social networks and ride-hailing. The increasing shift towards e-commerce has also been presented as a key force that is transforming retail markets, with broader implications for price-setting

behaviour and inflation outcomes. E-commerce lowers the costs of gathering information on prices and product offerings across sellers, allowing consumers to observe more easily the distribution of product prices and verify the quality of the products they intend to purchase.

The widespread availability of price and product information online should, in theory, reduce the pricing power of sellers by making it costless for

² The Riksbank (2015) and the Bank of Canada (2017) have documented a similar decline in ICT-related CPI components over the past two decades for Sweden and Canada, respectively. The components of the ‘ICT-related’ category in Charts 1a and 1b above were selected to match those used in the above studies as closely as possible. However, certain CPI components intended to capture the effect of digitalisation on traditional goods, such as reading materials and textbooks, were excluded from the analysis.

consumers to seek a better price and greater variety elsewhere. Conversely, for sellers, the ability to change prices nearly instantaneously online lowers ‘menu’ costs, allowing prices to adjust more flexibly in response to shifts in demand and supply. The transparency of online platforms also enables sellers to quickly assess the demand for their own products and the pricing decisions of their competitors, which improves market efficiency (Lieber and Syverson, 2012). Online retailers typically have lower fixed cost structures compared to their brick-and-mortar counterparts, and are able to minimise inventory holding costs. They are also able to submit orders to wholesalers and third-party providers for processing and shipping directly to consumers, thus reducing distribution costs.

Through increased competition as a result of greater transparency in online markets, as well as lower overhead and distribution costs, e-commerce can act to reduce prices online. There is empirical evidence from studies of specific markets ranging from life insurance (Brown and Goolsbee, 2002), airlines (Sengupta and Wiggins, 2006; Itai and Orlov, 2015) to bookstores (Brynjolfsson and Smith, 2000) that online prices tend to be lower than those offline. At the aggregate level, some studies find that e-commerce has had a modest disinflationary impact. The European Central Bank (2017) found that increasing e-commerce adoption had a small but statistically significant effect on inflation, such that a one percentage point increase in the number of individuals looking for goods and services online contributed to a 0.025 percentage point decline in annual non-energy industrial goods inflation across the EU countries in their sample. This in turn translated into a 0.1% point decrease in inflation each year from 2003–15.

Popular accounts cite competition between online and brick-and-mortar retailers—or the ‘Amazon Effect’—as having eroded retail mark-ups, placing downward pressure on prices.

Analysing a large sample of products sold by Walmart and other large retailers in the US that sell both online and offline, Cavallo (2018) showed that products that were more easily found on Amazon exhibited more frequent price changes and were also more likely to be uniform across geographical locations. Moreover, the similarity in the pricing of online and offline products could reflect the use of algorithmic pricing strategies and the ability to monitor competitors’ prices constantly online.

Distance is now also a less important source of friction for exchange in e-commerce markets. Lower search costs online and the ability to ship directly to consumers enable online retailers to expand their reach, while making it harder for retailers to corner geographically segmented markets (Lieber and Syverson, 2012). This increasing contestability of domestic markets through online channels can be seen as having parallels to the ‘unbundling’ of production into global value chains over the past decade (Baldwin, 2017).

The entry of foreign online retailers can intensify retail competition by allowing consumers and businesses to bypass local intermediaries in purchasing from sellers abroad, placing downward pressure on the margins of domestic retailers (Reserve Bank of Australia, 2016). Retailers based offshore may enjoy a cost advantage *vis-à-vis* domestic retailers, and by aggregating demand over a larger market, are able to offer a greater variety of goods compared to their domestic counterparts. Indeed, greater choice online and the lack of local availability are among the top reasons cited by Singaporeans for buying from foreign e-commerce sites.³

Relatively thinner mark-ups for online retailers⁴, and the effects of online competition on the margins of traditional retailers could increase the sensitivity of prices to cost shocks. Consistent with a growing body of research studying the

³ In a survey by BP Post International published on Export.gov, a market intelligence portal for US companies exporting abroad by the US Commercial Service, 48% of Singaporean respondents indicated that greater choice was the reason for their purchases from foreign e-commerce sites. The other top reasons mentioned were the lack of local availability, lower cost, better discounts and a strong Singapore dollar.

⁴ Comparing the profit margins of Amazon (less than 4%) and Walmart (more than 20%), Gorodnichenko (2018) notes that significantly smaller profit margins of online-only retailers could reflect more intense price competition in e-commerce markets.

properties of online prices, Gorodnichenko and Talavera (2017) found that the pass-through of exchange rate movements to prices online was significantly higher at 60–75% compared to estimates of 20–40% for goods sold in regular stores. They attributed the relatively higher rate of exchange rate pass-through to the lower share of non-tradable costs in e-commerce transactions, as well as the more flexible adjustment of prices online. Comparing matched-product prices across countries scraped from the web, Cavallo (2018) similarly documents a sizeable increase in the impact of exchange rate movements on relative price levels over time for the US, with the magnitude of pass-through into relative prices over a two-year horizon (44%) significantly higher than estimates in other studies using retail CPI data, and approaching those of direct imports at the border.

Although they are more flexible compared to prices posted by brick-and-mortar stores, online prices can also be sticky for extended durations. In addition, they tend to adjust by a similar magnitude to offline prices, and there is little evidence of ‘dynamic pricing’, where sellers adjust their prices at a high frequency in response to changes in demand and supply conditions (Gorodnichenko *et al.*, 2017).

Gorodnichenko (2018) highlights the two-way strategic interactions between online and offline retailers as a potential explanation for this behaviour, noting that even as the share of retail spending on e-commerce rises, the continued presence of traditional brick-and-mortar retailers could constrain the ability of online retailers to set prices that differ too significantly.

The studies cited also note that despite reduced search costs and a greater degree of flexibility, there is still a significant degree of dispersion in prices online, even within narrowly-defined product categories. While part of this variation arises from differentiation across seller types and product quality, sellers can also manipulate the search process to insulate themselves from competition online (Goldfarb and Tucker, 2017).

For example, retailers can obfuscate their prices online by employing ‘bait-and-switch’ pricing strategies that attract consumers with lower-priced products before showing them more expensive or higher-quality items, or by withholding information on shipping fees and other ‘add-on’ costs (Ellison and Ellison, 2009; Hossain and Morgan, 2006). Recent allegations of unfair pricing practices by large online retailers and price search engines⁵ have also raised concerns that the network and scale economies enjoyed by dominant online platforms could result in ‘lock-in’ that stifles competition (Levin, 2011).

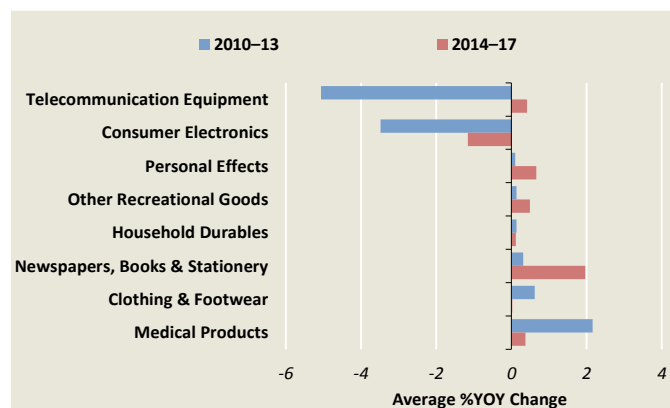
⁵ Notably, the European Commission ruled in June 2017 that Google had violated anti-trust regulations by giving its own comparison shopping service an illegal advantage over other web listings. More recently, the EU Competition Commission launched a preliminary investigation into whether Amazon’s collection of data on the activities of third-party merchants on its platform gave an unfair advantage to its own e-commerce business in September 2018 (Drozdiak and McLaughlin, 2018).

E-Commerce And Price Dynamics In Singapore

There has been a significant rise in e-commerce penetration in Singapore. According to the IMDA annual *Survey on Infocomm Usage in Households and Individuals*, the percentage of internet users indicating that they had purchased goods online rose from 8% in 2012 to 55% in 2017. While the share of online sales as a fraction of total retail sales remains relatively small at 4.6% as of August 2018⁶, it is projected to grow. In particular, growth in online purchases has been concentrated in certain categories of retail goods, such as clothing and electronic equipment, consistent with trends in other developed countries.⁷

The Singapore Department of Statistics has progressively incorporated online prices for items commonly purchased through online channels, such as travel products and apparel, into the CPI. While there are indications that the retail categories which have seen greater e-commerce penetration have also experienced lower inflation, a broader comparison of inflation rates across the main categories of retail goods does not suggest that retail price inflation has been significantly lower in recent years. (Chart 2)

Chart 2
Selected Components
of Retail Goods Inflation in Singapore



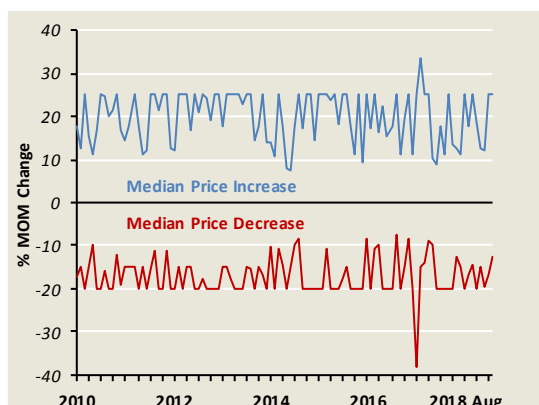
Examining individual price observations sampled in the CPI also suggests that the size of price changes for retail goods has remained largely stable. For instance, the median size of m-o-m percentage price changes for items in the 'Clothing & Footwear' CPI has remained remarkably stable over 2010 to 2017, despite accounts of intense competition between online and offline retailers in this product segment. (Chart 3a) At the same time, the percentage of observations experiencing price changes

from the previous month fell for the 'Clothing & Footwear' segment, although it has generally risen across other categories of retail goods in recent years—which appears less consistent with increased price flexibility due to online-offline competition. (Chart 3b) There is thus limited *prima facie* evidence from the CPI microdata that the price-setting behaviour of domestic retailers has changed significantly in response to increasing e-commerce penetration.

⁶ This figure cited in the press release of the August 2018 Retail Sales Index by DOS is likely to represent a lower-bound estimate of the share of online purchases as it excludes cross-border online transactions. Estimates by Forrester Research cited in the Export.gov report indicate that up to 60% of Singapore's e-commerce sales are from cross-border transactions.

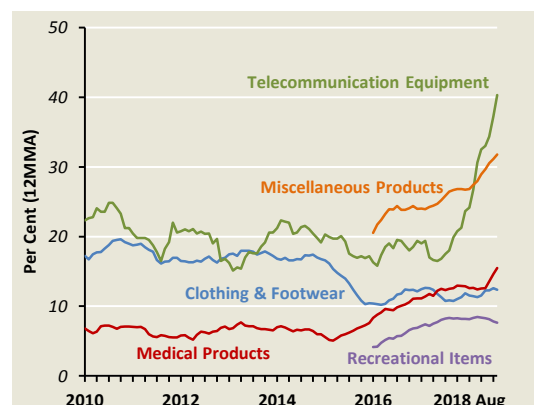
⁷ See, for example, Eurostat (2017).

Chart 3a
Median Price Changes of Items in the Clothing & Footwear CPI in Singapore



Note: Denotes the median m-on-m percentage price increase (decrease) of the total number of observations with price increases (decreases).

Chart 3b
Frequency of Price Changes for Selected Retail Goods in Singapore



Note: Computed as the unweighted percentage of price observations with non-zero price changes from the previous month over the total number of price observations. The 'Miscellaneous Products' category includes personal effects and personal care products, as well as alcohol & tobacco.

Emergence Of 'Near-Instant' Services Platforms

Apart from e-commerce, the emergence of large online platforms can reshape consumer behaviour and potentially influence longer-term price trends. New platforms that enable the offering of 'near-instant services', such as ride-hailing apps Grab and Uber (DotEcon, 2015) that challenge, and sometimes displace, incumbent players in the market can lower inflation through increased competition.

In Singapore, the average number of daily taxi trips per driver has fallen steeply in the years since Uber entered the domestic ride-hailing market in 2013, possibly on account of the intense competition between ride-hailing apps and traditional taxi operators.⁸ (Chart 4a) While the long-run impact on fares is indeterminate, especially if ride-sharing companies manage to dominate the market and acquire substantial pricing power, consumers currently enjoy an expanded range of travel options, as well as an effective reduction in fares. Indeed, the rate of increase in taxi fares has been muted at an average of 0.3% y-o-y over Q1 2013 – Q3 2018, a

significant step-down from 5.1% in 2008–2012. (Chart 4b) In addition to the impact on transport services inflation, the ubiquity of ride-hailing services has also shaped consumer perceptions about car ownership and transportation. The results of a survey by the Public Transport Council conducted in 2018 highlighted how Singaporeans were increasingly using ride-hailing services, with the proportion of respondents who took a private-hire car in the past seven days rising significantly to 70.5% in 2017 from 50% in 2016.

The shift towards ride-hailing services could arguably lower private road transport inflation in the longer term, as it is analogous to a positive productivity shock. The effective supply of transportation services provided for a given car or taxi fleet size is increased, since ride-sharing firms typically have higher utilisation rates per vehicle (Cramer and Krueger, 2016). Anecdotally, other service business models are similarly facing disruption. For instance, 'new-delivery' services such as UberEats and Deliveroo that aggregate customer orders online and coordinate delivery

⁸ In Singapore, ride-hailing service providers such as Grab maintain fleets of rental vehicles through subsidiaries that are leased to drivers providing chauffeured private-hire car services. As of August 2018, the population of private-hire cars was 66,998, more than triple the size of the taxi fleet (21,366). See Tan (2018).

logistics for restaurants are likely to see rapid growth in the near future, even though fewer than 30% of food orders are estimated to be made online today (McKinsey, 2017). This could have implications for prices in the F&B industry, given that ‘new-delivery’ services allow establishments that did not traditionally offer

catering services, such as hawker stalls and high-end restaurants, to access consumers through online channels. In a similar vein, AirBnB, which allows property owners to ‘home-share’ with guests, has led to an expansion of accommodation options that are cheaper than hotels.

Chart 4a
Average Number of Taxi Trips Daily
and Rental Car Population in Singapore

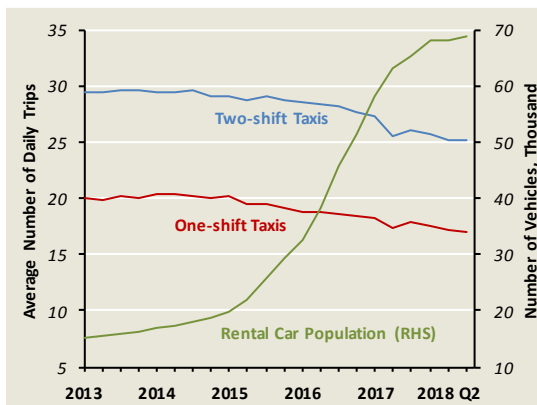
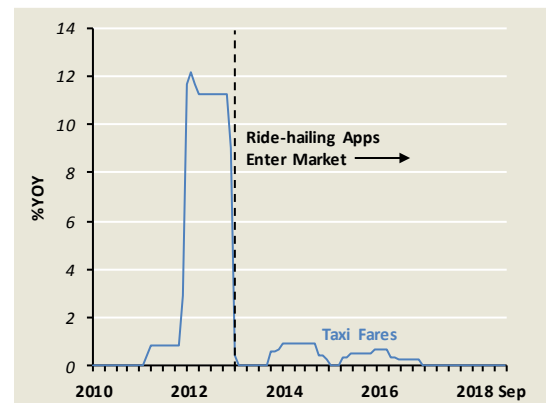


Chart 4b
CPI for Taxi Fares in Singapore



Sum-Up

Changes in price-setting behaviour by firms and consumption patterns as a result of technological progress can potentially influence inflation dynamics. More broadly, technology has fundamentally changed consumer purchasing habits, with its attendant implications for price-setting and inflation, as the shift towards e-commerce and disintermediation in retail continues apace.

The characteristics of online retail platforms—the ease of search and price comparison, less costly price adjustment for retailers and the removal of geographical barriers between consumers and businesses—have raised the possibility that inflation could respond more quickly to price and cost shocks. In particular, the influence of external factors on domestic inflation and the degree of exchange rate pass-through could change as global markets become increasingly interlinked, especially given that the share of cross-border e-commerce sales is likely to rise in Singapore. For instance, prices of goods sold online tend to be more responsive to movements in the exchange

rate, while competitive factors such as the entry of foreign online retailers could potentially explain why changes in retail prices diverge from corresponding movements in import prices.

The shift towards less labour-intensive e-commerce retailing models, as well as the realisation of productivity gains through the reduction of costs associated with transactions, inventory management and advertising online could also have implications for the responsiveness of inflation to domestic slack.

Furthermore, ‘near-instant’ services platforms may result in changes in consumption patterns that can shape longer-term price trends. In Singapore, there is some indication that e-commerce and the emergence of new digital platforms are placing downward pressure on consumer prices in certain segments through shifts in market structure and increased competition. However, current empirical evidence does not provide a clear indication of a structural decline in inflation going forward.

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