Impulse

Identity Management in PUbLic SErvices

# 4.3 Economic Benefits of the IMPULSE Approach – V1

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# Executive summary

This Deliverable analyses the potential economic impact that deployment of the IMPULSE eID solution might yield in specific pilot use cases. The Deliverable first reviews the relevant literature on the economics of digital identity and digital government. It then analyses the expected impact of IMPULSE in the pilot use cases explored in the project, providing quantitative estimates where feasible. The general conclusion is that in some, though not all, use cases, IMPULSE can increase the efficiency and ease of public service provision. Where this is the case, the public administrations should enjoy modest monetary savings, largely by reducing the amount of labour (time) required to complete various administrative tasks. For citizens, the main direct economic benefit of IMPULSE are time savings. Depending on the context and use case, the system may cut the time required for citizens to obtain a particular service by an hour or more. These findings are broadly in line with the extant literature, which predicts that in advanced economies, basic digital identity solutions (i.e., those that mainly offer authentication services) like IMPULSE should mainly yield modest efficiency gains. Larger economic gains from the implementation of digital identities are possible, but they depend on (i) making large numbers of different public and private sector use cases available via the digital identity; (ii) adding "advanced" functionalities to the digital identity system, in particular a digital wallet and/or qualified electronic signature functionality.

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# Abbreviations and acronyms

| | |
|---|---|
| **BGN** | Bulgarian lev |
| **DKK** | Danish Krone |
| **DSGV** | Deutscher Sparkassen- und Giroverband |
| **EC** | European Commission |
| **EU** | European Union |
| **EEA** | European Economic Area |
| **eID** | electronic identity |
| **GDP** | Gross Domestic Product |
| **ICT** | Information and Communication Technologies |
| **NIST** | National Institute of Standards and Technology |
| **OECD** | Organisation for Economic Cooperation and Development |
| **QES** | Qualified Electronic Signature |
| **SSI** | Self-Sovereign Identity |
| **TUM** | Technische Universität München |
| **VC** | Verifiable Credential |
| **ZKP** | Zero Knowledge Proof |

# 1 Introduction

This report sets out the first version of the Deliverable studying the likely socio-economic impact of the IMPULSE electronic identity (eID) solution (Deliverable 4.2). The main question it tries to answer is, what are the likely (socio-) economic effects that the IMPULSE eID solution might have, if implemented "for real" in the five Pilot Use Cases developed within the IMPULSE project, as well as beyond. To answer this question, the Deliverable employs a mix of approaches, including a review of the extant literature on the economics of electronic identity and digital government, and quantitative estimations and analysis of the possible effects of IMPULSE in the Pilot Use Cases based on interviews with the case owners and original data collected from their organisations. Due to the variety of approaches used, the Deliverable does not include a separate chapter on methodology. Instead, a separate methodology section is included in each chapter, where relevant.

The text is organised as follows. Chapter 2 frames the following analysis through a discussion of some key underlying concepts. Chapter 3 then presents the review of the literature. Chapter 4 examines economic impacts of IMPULSE in the Pilot Cases under different scenarios. Chapter 5 concludes.

# 2 Conceptual considerations and detailed research questions

IMPULSE is an **eID solution** that is currently being tried in various **digital government** use cases. The main function of IMPULSE in its current instantiation is **authentication/log-in** through biometric means (facial recognition), though **digital wallet** and **digital signature** functionalities are likely to be added in the future. IMPULSE belongs to the class of **self-sovereign identity** (SSI) solutions. To properly understand what effects IMPULSE in its current and future forms may and may *not* have, it is important to properly understand the distinctions between these concepts. The purpose of this chapter is to lay these out.

## 2.1 How IMPULSE works

A full description of how IMPULSE works is beyond the remit of this paper, and basic familiarity of the reader with the functionality of IMPULSE is assumed.[1] In a nutshell, however, IMPULSE works as an App on the user's smartphone, through which the user can create digital (electronic) identities for herself, to register and authenticate to online services. To do so, the user accesses the website of the online service, clicks "Sign up with IMPULSE" (or a similar link, possibly in QR-code form), which opens up the IMPULSE application on her smartphone. She next takes a photo of each side of her identity document (e.g. state identity card, passport) as well as a photo of her face (selfie), and uploads these to the IMPULSE enterprise server via the app. IMPULSE then uses artificial intelligence to check that the selfie and the user's photo on her identity document match, and that the identity document is not fraudulent. Information about the user required by the online service (e.g. name, date of birth, etc.) is automatically extracted from the card or entered manually by the user, if not contained on her identity document (e.g. personal hobbies). The IMPULSE system creates a digital identity for the online service in question, and stores this in the secure element on the user's smartphone. This digital identity contains biometric information (a "biometric profile") derived from the selfie to enable the user to authenticate herself via facial recognition. The photographs are erased from the system. To log in to the online service, the user then simply accesses the service website, selects "Log in with IMPULSE" (or similar), which opens the IMPULSE app on her smartphone. She selects the digital identity for the service, and again takes a photo of her face. IMPULSE checks that the photo and the biometric profile contained in the digital identity match. If they match, she is authenticated and logged in to the service. The photograph she just took is again erased.

[1] For detailed technical discussion of the IMPULSE solution, see Deliverables 5.1–5.4 of the IMPULSE project. The following video provides a basic overview of how IMPULSE works from the user perspective: https://www.youtube.com/watch?v=P3j-xJK5fXA

## 2.2 Digital government, electronic identity, authentication, digital wallet and digital signature, SSI

At its most basic, **digital government** refers to "the production and delivery of [government] information and services … [by] using a range of information and communication technologies" (Fountain 2004). Beyond this basic understanding, as the full potential of digital technology and digital processes have gradually come to be recognised, "digital government" has increasingly come to be understood as constituting a fundamental shift in how public services are delivered and what they even consist of, towards a more data-driven, accountable, transparent and more interactive and demand-/needs-oriented mode of administration and service delivery (World Bank n.d.; OECD 2019).[2] There is good reason to believe that achieving comprehensive "digital government" in this more ambitious sense will yield substantial economic benefits, including efficiency savings, higher growth, employment and company creation, as well as increased use of public services. Most of the use cases explored in the IMPULSE pilots can be considered instances of "digital government". What economic effect the digitisation of discrete government tasks and processes yields, will of course depend on the details of the use case, and it is possible that the full economic potential can only be reached as broad swaths of public administration are digitized, not just individual use cases.

An **electronic identity**, **eID**, or **digital identity**[3] is an electronic/digital means for entities (citizens, businesses, machines, etc.) to prove who they say they are, via a digital channel (European Commission n.d.; White et al. 2019). A digital identity thus includes a subset of attributes about the entity (e.g. name, date of birth) that uniquely identify it within a given set of other entities (Gritzalis and Lambrinoudakis 2008), with the composition of this subset varying by use case. Digital identity is a key building block for the realisation of digital government (Vassil 2016; White et al. 2019); however, by itself it is *not* digital government, and providing citizens or companies with digital identities alone will not achieve the economic (or social and political) benefits digital government promises.

As both McKinsey (White et al. 2019) and Echikson (2020) note, it is helpful to distinguish between "basic" digital identity, which enables only authentication (see next), and "advanced" digital identity, which allows additional information about the individual to be electronically stored in the eID or automatically linked to it (e.g. via digital wallets, see below). The IMPULSE solution at present is a tool to provide people only with a basic digital identity, but planned future developments (e.g. wallet functionality) would turn it into an advanced eID.

**Authentication**, or, from the user's perspective, **Log-In**, is the act of verifying that a user is indeed who they claim to be, including verifying that the attributes they claim are true. It is a common prerequisite for allowing a user access to certain services or resources (NIST n.d.). Many different authentication technologies for eIDs exist today; e.g. password and username, smartcard or USB stick and PIN, or biometrics (finger print, iris scan, facial or voice recognition). Broadly speaking, password/username is likely the most commonly used authentication technology today. Smartcards seem to be mainly still used in legacy systems and are often gradually being supplanted with newer technology. Biometric systems are increasingly common. IMPULSE uses facial recognition to authenticate users. As further discussed in Chapter 4, the technologies currently deployed in the Pilot use cases include smartcards, USB sticks, usernames and passwords, or purely analog means of authentication (e.g. appearing in person with one's physical identity card). One question for IMPULSE is whether different authentication technologies have qualitatively or quantitatively distinct economic (as well as social and political) impacts.

[2] Scholars sometimes distinguish between "e-government" – the introduction of information and communication technology (ICT) to carry out tasks previously performed by analog means, but without changing the nature of the tasks or the organisation of the processes themselves (what I called the "basic" understanding of digital government above) – and "digital government" proper; that is, the transformation of the tasks and processes of public administration themselves to take advantage of the full potentials of digital technology (OECD 2019: p. 148).

[3] For sake of linguistic variation, this text uses the three terms electronic identity, eID and digital identity interchangeably.

**Digital** or **electronic signature** is a function included in some electronic identity systems that enables the user to provide a legally-binding signature on electronic documents (sometimes also referred to as a "qualified electronic signature" or QES). The IMPULSE system currently does not include a QES function. Including it would require further technical development as well as legal-regulatory certification. The ability to provide legally-binding digital signatures is likely crucial to enable many higher-value use cases in both the public and private sector (e.g. taking on mortgages, applying for various permits). That IMPULSE currently still lacks this functionality must be borne in mind when assessing its potential economic impacts.

**Digital wallets** are applications (or functions within larger applications) within which users can store certain types of information, such as payment information, credentials or certificates, including electronic versions of physical documents like driver's licenses or university records. Modern digital identity systems increasingly include digital wallets, allowing users to digitally present and prove their possession of diverse certificates and credentials. The current instantiation of the IMPULSE system does not include a digital wallet, but development of one is planned for the future. Nor do the current pilot use cases require a wallet. Again, to assess the full possible impact of IMPULSE, the implications of its current lack of a wallet function, and the opportunities offered by its future inclusion, must be considered.

**Self-sovereign identity (SSI)** is one family of digital identity technologies, to which also IMPULSE belongs. The main idea of SSI is that the user is to be put in complete control of her data. This is accomplished by storing the data (e.g. an identity credential or a certificate like an electronic driving license) only on the user's own device (e.g. a smartphone), usually in a digital wallet.[4] The user can then decide in a "sovereign" fashion, to whom to give access to the data. The SSI model of identity management is distinct from centralised, federated and "user centric" identity management models, which currently still predominate. While in SSI the user's data is stored only on the user device (and with any service providers the user chooses to give access to the data to), in centralised as well as federated/"user centric" systems, the identity provider remains in possession of the user's data (centralised system) and is able to track which services the user authenticates to (federated and user centric models).[5] One question for the economic assessment of IMPULSE is whether, as an SSI system, it has qualitatively different economic implications to other kinds of eID systems.

## 2.3 Research questions

The above discussion implies that IMPULSE may unleash economic effects through two pathways: (i) by enabling digital government, (ii) by enabling digital transactions in the private sector. The IMPULSE project explores these effects through the six pilot cases. Research questions 1 and 2 are thus:

1) What are the specific economic effects of using IMPULSE in the pilot cases?
2) How large are the economic effects in the pilot cases?

The architecture of IMPULSE (SSI, with biometrics for authentication and Wallet and QES functionalities potentially available in future) raises further research questions:

3) Does the use of biometrics for authentication give IMPULSE distinct economic effects, compared to other authentication technologies?
4) What economic effects could adding a Digital Wallet and QES functionality to IMPULSE have? What are the economic effects of their current lack?
5) Does being an SSI solution give IMPULSE particular economic effects, that other eID architectures will necessarily lack?

[4] For security reasons, the data is usually only stored in an encrypted format, and/or in a secure element on the device.
[5] For detailed discussion of the differences between these various approaches to identity management see Strüker et al. (2021). For details on the IMPULSE system's architecture see Deliverables 5.1 – 5.4.

# 3 Review of the Literature

To better understand the possible effects of IMPULSE and eID systems in general, we reviewed the relevant literature.

## 3.1 Method

To identify relevant literature for both the economic (Deliverable 4.3) and the social and political impact assessments (Deliverable 4.1), we first searched the "Economics" and "Social Sciences" sections of the SCOPUS journal database for articles with any of the following keywords in their titles or abstracts:

> *Digital identity OR electronic identity OR eID OR digital personal identity OR digital government OR e-government OR self sovereign OR sovereign identity OR SSI*

This returned 362 documents (journal articles) from the "Economics" section, and 427 from the "Social Sciences" section (including a large number of duplicates between the two searches). The abstracts of these articles were then read to identify articles potentially relevant to the research questions at hand. This yielded about ~60 papers, which we studied. While these numbers appear to suggest that a large scholarly literature on the economic and social/political impacts of digital identity as well as on questions of acceptance exists, this is not in fact so. Many papers had only tangential relevance (e.g. technical papers proposing novel eID or digital government schemes), and/or were mainly conceptual and included no empirical data on the questions of interest. Therefore, when reading the papers, we also followed up their footnotes to identify further papers and relevant "grey literature". Indeed, the grey literature – mostly practically-oriented reports from international organisations or consultancies – often proved the most helpful. This review summarises the main points of relevance.

## 3.2 Results

It is helpful to discuss the economic impacts of digital identity on the public and the private sector separately, and then deal with the narrower questions of the economic effects of different authentication technologies, digital wallets, signatures and "self sovereign identity" architectures.

### 3.2.1 Economic impacts of digital identity in the public sector

The World Bank "Identification for Development"-Project and the consulting company McKinsey have produced the most systematic recent studies of the impact of (digital) identity on the public sector (World Bank 2018a, 2018b; White et al. 2019). Both find that the impact of providing citizens and businesses with digital identities can be substantial, though making specific quantitative estimates is difficult. McKinsey (White et al. 2019) does try to calculate what the aggregate economic impact across both the public and private sector would be for seven "focus countries"[6], were digital identity to be widely adopted by their populations. The estimates range from 3 to 13 percent of GDP by 2030 depending on country, with the higher ranges found in Global South countries. The Bank, conversely, refrains from country- or even sector-specific quantitative estimates, noting the "scarcity of publicly available data" and unresolved "methodological challenges … with quantifying and attributing the effects of [identity] systems" (World Bank 2018a: p. vi). Instead, the focus is on identifying causal mechanisms through which economic effects take place. More broadly, the World Bank (2018a) cautions that observed effects and effect sizes are highly dependent on country characteristics, including:

- Share of the population that has (no) form of official identification (e.g. state identity card)
- Size of the informal sector of the economy
- Prevalence and scale of tax evasion
- Prevalence and scale of fraud, corruption and errors in public services provision and public employment (e.g. ghost workers, deceased pensions claimants still on the books; benefits fraud)

[6] Brazil, China, Ethiopia, India, Nigeria, United Kingdom and United States.

- Role (if any) of intermediary actors (e.g. local businesses, churches, NGOs, local leaders) in mediating access to public services and state-citizen interactions
- Availability of internet access and ICT
- General development and wage level.

Generally speaking, (positive) economic effects of providing citizens with digital identity are larger in countries where a significant share of the population still lacks official identification, where the informal sector is large, existing public population and benefits registers are error-prone, non-state intermediaries play important roles in public service/benefits provision, and tax evasion, fraud and corruption are more prevalent (World Bank 2018a; White et al. 2019). Conversely, lower levels of internet and ICT availability as well as higher wage and development levels push up the costs of building and rolling out digital identity systems.

The literature points to three main mechanisms through which positive economic effects for the public sector are achieved: formalisation, reduction of fraud, corruption and errors, and efficiency savings.

#### 3.2.1.1 Formalisation: public sector effects

This refers to bringing people and business activities into the formal sector. Lack of a legal (officially recognised) identity is often a fundamental barrier to participation in the formal economy, whether as an employee or as an entrepreneur. Without a legally-recognised identity, people are commonly unable to access bank credit (except on usurious terms), get a bank account or insurance or pensions coverage. They are also often unable to access government services. This in turn severely hampers economic productivity, not to mention life opportunities (World Bank 2018a, 2018b, 2019; Elgin et al. 2021; Addo and Senyo 2021). For the public sector, the informal sector is often hard to tax. Formalisation thus raises the tax take both directly (identified individuals and businesses can now be taxed) and through second-order effects (greater economic activity results in more taxes).

By some estimates, worldwide more than 1,5 billion people do not have a legally-recognised identity (Wang and Filippi 2020). Rolling out digital identity programs and technologies is seen as a means to provide people without a legal identity with one, and thus bring them into the formal sector (World Bank Group 2018a, White et al. 2019, Wang and Filippi 2020, López 2020, World Economic Forum 2018).

However, these people are largely concentrated in developing countries. In developed countries, most citizens and residents already have a legal identity. In the European Union (EU) and European Economic Area (EEA) states, between 95 and 99 percent of the population already has a legal identity (World Bank 2019). Moreover, access to identity in these states is usually straightforward and inexpensive.[7] This suggests that the reason why a small share of the population remains without a legal identity are complex and unlikely to be resolved by simply introducing a new piece of technology. The IMPULSE solution, in any case, requires the user to *already* possess a valid state identity card or passport. It is not intended as a tool to help people without identity obtain a legal identity for the first time, and cannot be used for this.

In developed countries, the informal sector is also significantly smaller than in developing countries. Estimates by Elgin et al. (2021) suggest that the informal sector in the EEA countries plus the United Kingdom is ~20 percent of GDP, compared to ~34 percent in Africa and South America.[8] More importantly, informality in developed economies may often be a choice rather than a necessity driven by a lack of legal identity (e.g. self-employed who take on additional work "on the side", in parallel to their regular formal-sector work). This suggests that neither the greater provision of digital identities in general, nor use of the IMPULSE solution in particular, will in themselves do much to drive further formalisation of economic activity in developed countries. This conclusion is supported by the McKinsey (2019) study, which finds that in developed countries, providing "basic" digital identities (such as would suffice to formalise *involuntarily* informal economic activity

[7] According to data presented on Wikipedia, in Europe the fee for a working age citizen or resident for a new state identity card ranges from ~€1.8 (9 lei) in Romania to €61.5 in Austria, with most states charging between ~€10 and ~€30. See https://en.wikipedia.org/wiki/National_identity_cards_in_the_European_Economic_Area

[8] Own calculations based on the country data for 2017 and 2018 presented in Elgin et al. (2021).

and involuntarily "unidentified" individuals) would do little to drive additional growth and tax take. According to McKinsey, in developed countries only "advanced" digital identity solutions can do so. It should be noted that the present instantiation of the IMPULSE system (authentication services only) corresponds to what McKinsey labels a "basic" digital identity, while possible future instantiations involving wallets and QES functionalities would constitute an "advanced" digital identity.

#### 3.2.1.2 Reducing fraud, corruption, and errors

A major source of savings to the public sector from the provision of digital identities has been the reduction in instances of fraud, corruption and errors thus effected. Where state registries and databases are incomplete, poorly cross-checked and/or still paper-based, or where public benefits are distributed to the population via poorly-controlled and audited intermediaries (e.g. local businesses, religious organisations or local notables), it has often proved possible to add non-existent ("ghost") workers or non-entitled claimants to payroll or benefits and pensions registers, or keep deceased claimants or departed workers on the rolls. As importantly, this also is liable to lead to errors and gaps illegitimately excluding legitimate beneficiaries from full benefits or pensions provision, or to unequal distribution of benefits. Providing all citizens (or at least all public sector workers and benefits/pensions claimants) with a unique digital identity helps eliminate such cases. Anecdotal evidence from Asia and Africa catalogued in World Bank (2018a) suggests that savings can be considerable.

However, the literature again suggests that these effects will likely be largest in developing countries, and have much more limited relevance for Europe. For one, the extent of benefits/pensions and public-sector payroll fraud in European countries seems mostly fairly low.[9] For another, European countries mostly already have sophisticated electronic registries and databases for their public sector workers, benefits and pensions systems in place. Low hanging fruit in terms of fraud prevention and error correction are thus likely to have already been picked. In other words, the introduction of IMPULSE is unlikely to have a significant impact in this regard. As none of the use cases relate to this issue, it is not further pursued.

#### 3.2.1.3 Efficiency savings: public sector

Efficiency savings are the economic effect most frequently identified in the literature, both for the public and the private sector (e.g. World Bank 2018a, 2018b, 2019, White et al. 2019, Wang and Filippi 2020, Vassil 2016, Pignatelli et al. 2019, Nortal 2020, Echikson 2020, Wolfond 2017, Mahula et al. 2021, World Economic Forum 2018, Doerk et al. 2020). Transitioning to digital government (which relies on eID) enables two main forms of savings in the public sector. One is *material savings*, from paper, pens, postage, printing and phone calls, to office buildings and associated utilities costs, as processes are moved online and the need for paper-based and face-to-face processes is reduced. The second, and arguably easier to realise, are *time and labour savings*, for both public servants and citizens, when formerly analog, paper-based and in-person processes are digitised, as these are often more efficient.[10] While this *may* produce *monetary* savings for the public authority if staff numbers can be reduced, it should at least free up labour. The public administration may thus be able to redeploy its civil servants to focus on other, more valuable activities, and thereby raise the quality of public services and administration.[11] For citizens, time savings may be even greater, as in addition to more efficient processes, eID-enabled digital government should greatly reduce the need for them to appear in person at government offices, removing travel (and queuing!) time and expenses. It also removes the need to potentially take time off work to accommodate public offices' normal business hours. Besides added convenience, this also helps make public services more accessible, e.g. to people who live further away from government offices, have little time (e.g. parents with young families) or inflexible working conditions.

[9] For example, official estimates for the UK (which has some of the most systematic data on the topic) indicate that incidents of benefits fraud ranged from 0.3 to 3.9 percent of spending, depending on the benefit in question (Geiger 2018; see also Rand 2014). Investigations into fraud and error in cross-country social security coordination in the EU paint a similar picture (Jorens et al. 2015).

[10] Note that digitisation also facilitates automation, further saving time and labour.

[11] Indeed, given the growing difficulty of recruiting new staff in aging societies, reducing the amount of labour needed to perform public services may be crucial even to maintain them at their current level, never mind increase their quality.

At the same time, the overall economic savings thus achievable should also not be overstated. For example, Vassil (2016) estimates that in 2014, the Estonian "X-Road" digital government system saved Estonian citizens a total of 2.8 million hours of time – or 2.13 hours per person.[12] More optimistically, McKinsey (2019) estimates that the comprehensive implementation of digital identities and digital government could save Americans about 4.4 billion hours a year in 2030, or 12.5 hours per person[13] and Brits 450 million hours, or 6.5 hours per person. Very convenient, no doubt, but not an economic revolution. Similarly, a UK Cabinet Office estimate in 2012 suggested that annual savings of between GBP 1.7 and 2.4 billion could be possible, if most state-citizen transactions were moved online (cited in World Bank 2018a). It should be noted that this would represent ~0,25 to ~0,35 percent of 2012 UK government spending,[14] and most savings (78%) were to come from reducing the number of civil servants, which may not necessarily be feasible in the short term (see below).

Indeed, *monetary* savings (as opposed to time/labour savings) from digital government and digital identity may be harder and slower to realise than expected. For one, it is very likely that governments will have to retain the analog (face-to-face) option for accessing public services for equity reasons. Not all citizens have smartphones (which are generally necessary for digital identities), or feel comfortable with or even *want to* use digital government processes (fortiss and Initiative D21 2018; TUM and Initiative D21 2020). This restricts the degree to which civil servant numbers can be cut, or buildings and other assets liquidated. Even when nominal savings *are* realised, these may not be easily converted into cash. For instance, selling off or renting out a fraction of a building may not always be feasible. Third, both theoretical estimates and empirical experience in e.g. Estonia tend to suggest that large savings only materialise once (i) a wide range of public services and public systems are digitised and connected (thus permitting rapid data exchange between different parts of the public administration), and (ii) digital government is widely adopted by the population, with a number of estimates suggesting adoption rates upwards of 80% may be necessary (World Bank Group 2018a, 2018b, citing an Asian Development Bank study, the 2012 UK Cabinet Office estimate and further "anecdotal research"; Vassil 2016; White et al. 2019). While the Estonian experience suggests that achieving high adoption rates is feasible over time even if the population is initially sceptical or disinterested, this is also likely to take several years, during which the upfront investment costs for the system must be borne but savings are not yet being realised (see data on adoption presented in Vassil 2016). Finally, to the extent that digital government makes public services more accessible, this may lead to *increased* services consumption, which militates against achieving savings. (Of course, increasing services consumption may be an policy objective in itself, e.g. to improve equity.)

#### 3.2.1.4 Public sector economic impact: initial conclusion from the literature

In summary, the following conclusions on the public-sector economic impact can be derived from the literature:

- Impacts are likely to be largest in developing countries and smaller in developed economies.
- Formalisation of hitherto involuntarily-informal sectors and reducing fraud and corruption are important drivers of the positive economic benefits in developing countries, but much less relevant in developed countries.
- Conversely the main positive economic effect for the public sector to be expected in developed economies are efficiency gains. Aside from enabling monetary savings, labour-saving efficiency gains through should also help secure current levels of service provision in the face of demographic change and labour/skills shortages
- Realising significant efficiency gains, however, likely depends on digital identities and digital government being widely adopted by the population, and on the comprehensive digitisation of

[12] Own calculation based on data presented in Vassil (2016) and Eurostat.
[13] Own calculations on the basis of UN Population Prospects data, which estimates the 2030 US population at 352.16 million, and the UK population at 69.18 million
[14] Own calculation from data presented in The Guardian (2012).

government services: digitising individual systems and processes alone is unlikely to pay large benefits.

- Even if direct economic benefits to the public sector are limited, it is still highly advisable to provide the public with digital identities and move to digital government: aside from the private-sector economic benefits this may realise (see below), digital identities and digital government can help drive inclusion and can significantly improve citizen convenience.

### 3.2.2 Economic impacts of digital identity in the private sector

As the World Bank (2018b) notes, identity "touches nearly every transaction" and thus it is to be expected that building a functioning, widely adopted digital identity system should deliver substantial economic benefits to the private sector. Nevertheless, quantifying these effects is challenging, for they are mostly "diffuse and second-order effects". "Rigorous research and reliable data" on the economic impact of identity systems on the private (as on the public) sector are "scarce" (World Bank 2018b). Broad measures like GDP growth or Ease of Doing Business scales are very noisy, while generalising from specific use cases – which can be found across many sectors – is difficult (ibid.).

Broadly speaking, four sets of effects can be derived from the literature, which partly parallel the effects on the public sector identified above.

#### 3.2.2.1 Formalisation: private sector effects

While the public sector benefits economically from formalisation mainly through increased tax take, the private sector benefits directly: Bringing more people into the formal economy drives growth and thus private-sector profits by enabling companies to transact more easily with more people and businesses. In particular, it increases the available pool of potential employees, and makes it easier to issue financial and insurance products to people (World Bank Group 2018b, 2019, White et al. 2019, World Economic Forum 2018).

#### 3.2.2.2 Efficiency savings and increased transactions in the private sector

Many contexts exist where businesses need to verify the identity of a potential customer, employee or business partner, and/or register their details to their systems (onboarding), both for compliance reasons and to reduce their own risk of falling victim to fraud. When identity systems are fragmented, paper-based and/or riven with errors and duplications, this requires substantial amounts of work and time for both the business and the customer, employee or business partner (Doerk et al. 2020, Dunphy et al. 2018, Wolfond 2017, White et al. 2019, World Bank 2018b). The longer and more complex the onboarding/identity verification process, the greater also the risk that the customer, etc., will break off (abandon) the process, or not initiate it in the first place (Richter and Anke 2021, von Schorlemer 2022).[15] Authoritative, general purpose digital identity systems that businesses can directly query, can reduce these costs substantially. In one example, the (very widely used, cf. Eaton et al. (2018) Norwegian BankID system, cut time associated with applying for university housing from 10-14 days to 1-3 days. Small savings too can add up: identity technology introduced in Dubai Airport cut time required for identity checks by 9-12 seconds per passenger, which at ~84 million passengers in 2016 would save up to 105-140 person *years* in administrative work (both examples taken from World Bank 2018b; own calculations). By making transactions easier and faster, digital identity systems should also be able to stimulate increased economic activity.

It should be noted that especially in advanced economies, reaping the full benefits of digital identity systems likely requires these to be *advanced* identity systems, that is equipped with QES functionality (so that legally-binding digital signatures can be given and the entire process take place solely online) and with digital wallets. This is discussed further in the section on economic effects of SSI.

[15] Experian claims that almost 50% of initiated online transactions are ultimately abandoned by customers before completion, often due to the friction in the onboarding and verification process. (Cited in World Bank 2018b). Survey evidence from German, Austria and Switzerland finds that ~47 percent of respondents have failed to initiate transactions (access services) because they did not want to have to create another digital identity (fortiss und Initiative D21 2019)

#### 3.2.2.3 Improved security

Despite the substantial costs invested in verification processes, companies and individuals nevertheless still frequently fall victim to fraud. Reliable numbers are hard to come by, but one estimate reported in Dunphy et al. 2018 is that identity fraud affected some 15 million Americans in 2016, creating ~$16 billion in damages.[16] Robust digital identities can substantially reduce the incidence of identity fraud and associated costs.

#### 3.2.2.4 Sale of identity-related services

Companies can sell digital identity system-related products and services to governments, businesses and end consumers. Indeed, in Europe this is an increasingly crowded market with both strong incumbents (e.g. in Scandinavia and the Baltics) and numerous start-up activities. Services include, inter alia, identity verification (fee per query), issuance of certificates, QES, and underlying digital components (e.g. wallets, blockchains) ( World Bank 2018b, European Commission 2020).

### 3.2.3 Economic impacts of different authentication technologies

Three broad types of authentication technology are in widespread use today; smartcards, passwords (including PIN/TAN systems) and, increasingly, biometrics (for a detailed overview of identity technologies see (World Bank 2018c). The comparative economic implications of these technologies seem to have been little-examined to date. Generally speaking, *username/password systems* are likely the cheapest, at least up front. They are also very flexible and easy to use on both mobile and desktop applications. However, they have at least two disadvantages that are liable also to impose economic costs. Firstly, users are prone to choosing simple passwords, with low security guarantees. If this leads to hacks or identity theft, potentially substantial additional costs on the user and/or related businesses and public administrations are imposed. Secondly, users often forget their passwords or usernames (Wolfond 2017). This is liable to directly reduce the volume of service consumption, if users abandon an initiated transaction or refrain from even accessing a service, rather than go through the process of requesting a new password. Representative surveys of users in Germany, Austria and Switzerland found that ~47 percent had forgotten passwords, and between 41 and 47 percent had not accessed services due to the hassle involved in creating a new digital identity (which is comparable to – and in the users' minds may also cover – creating a new password) (fortiss und Initiative D21 2019). Lost passwords and usernames also create direct costs for businesses in the form of additional helpdesk requests. Data on this phenomenon, too, is scarce, but one often cited figure from Accenture (2013) found that ~30 percent of calls to UK banks' customer service centres concern lost passwords, with each call costing banks about US$25 (cited in World Bank 2018b).

Several types of *card systems* for digital identity are in use today (World Bank 2018c). The most common in the context of digital government are *contact smart cards*, which have an embedded microchip that is read with a card reader (ibid.). They have been used for digital government applications in Germany, Estonia, and Belgium, among other countries (Felden et al. 2020, Vassil 2016, Mahula et al. 2021, World Bank 2019). While they are generally more secure than password-based systems, they are less flexible. Since a reader is required, it is difficult to use them outside of a desktop context, which may reduce the frequency of transactions. Furthermore, the hardware is relatively expensive, with card readers costing between €20 and €90, depending on the security of the model. Reliance on smart cards and card readers has thus reduced uptake of digital identities and digital government among populations in Europe (Felden et al. 2020, fortiss and Initiative D21 2018), and these systems seem to be generally on the way out today. It is worth noting that, unless they are heavily subsidised, smart card and reader systems are likely to enjoy particularly *low* uptake among poorer sections of the population, due to their cost.

*Biometrics* include fingerprint, iris, facial and voice recognition. Fingerprint and facial recognition, in particular, are used increasingly widely for mobile phones (World Bank 2018c). Economically, they have the

[16] It should be noted that identity fraud may be more prevalent in the United States than in Europe, because unlike most European countries, the U.S. does not issue its citizens with a universal, state identity document (passports are voluntary, and many Americans do not have one).

advantage over password systems that they dispense with the problem of forgotten or insecure passwords, and over smart cards, that they dispense with the need for costly and inflexible hardware.

### 3.2.4 Self-sovereign Identity, Digital Wallets, and Electronic Signatures

Self-sovereign identity (SSI) is a relatively new approach to identity. The term seems to have been first coined by Christopher Allen (2016). The core idea of SSI is to give users more direct control over their identity and associated data, by disintermediating central or federated identity providers, like state agencies or private companies (e.g. "Log in with Gmail").[17] Architecturally, this is accomplished by storing the relevant identity data with the user, and *only* with the user (usually on their smartphone), at least until they decide to share it with a service provider in the context of accessing or registering for a service (e.g. providing a bank with their identity information in order to open a bank account).

In practical terms, the identity data is stored as so-called Verifiable Credentials (VCs) in the "digital wallet", a secure compartment in the SSI application on the user's smartphone or other device. VCs are essentially cryptographically secured digital credentials that are issued and signed by an issuing authority (e.g. a state agency, a university, a service provider). All manner of credentials can be issued as digital VCs and stored in a digital wallet; state identity cards, driving licenses, university certificates, registration/subscription (user account) information for some online service, etc. The user can then digitally present his VCs to counterparties, who can automatically verify these credential's authenticity by reading the credential content and signature of the issuing authority. The process is somewhat analogous to, for example, taking one's physical driving license out of one's physical wallet and presenting it to a car rental agency when hiring a car, to prove one's right to drive, and then returning the credential to one's wallet. The point is that the user retains control over the credential (VC). It does not pass into the possession of the rental agency or digital service provider (though both the rental agency, in the physical-world example, and the digital service provider in the digital case, may insist on noting down some of the information about the user thus presented to them in their own systems.) If SSI is combined with Zero Knowledge Proofs (ZKPs), the data shared with service providers can be further minimised.[18]

The contrast here is with both centralised identity systems, where all the identity data is stored in a central repository controlled by the identity provider (e.g. a state agency that issues passports), and with federated identity providers like Google (Gmail), where the provider retains at least the core attributes associated with an identity (e.g. name) and can track which online services the user accesses with the identity, to profile the user (Strüker et al. 2021). Because they can be cryptographically secured, VCs are also highly tamper- and fraud-proof – *far* more so than the pdf scans and photographs of physical documents, through which credentials are often still shared today.

While SSI has garnered considerable interest in the tech scene and, to some extent, among business circles (e.g. von Schorlemer 2022, Doerk et al. 2020, Deutscher Sparkassen- und Giroverband et al. 2021), research into the possible economic effects specifically of *SSI* has remained very limited so far (Kubach and Sellung 2021). Several papers have begun to examine possible business models in SSI ecosystems (Richter and Anke 2021, Stockburger et al. 2021), European Commission 2020, Kubach and Sellung 2021, Wang and Filippi 2020, Echikson 2020), though they too note that, to date, SSI-related business models "remain underspecified" (European Commission 2020). Rather than strictly economic benefits, the advantages most often ascribed to

[17] The degree to which SSI approaches could truly disintermediate *state* identity providers is questionable. Generally speaking, identities are valuable to the extent to which third parties (public agencies, private companies) recognise them as legitimate. To date, the most powerful legitimation of an identity remains its recognition by the state, and states generally recognise only the identities that were issued by themselves or by other states. Businesses too tend to require a state-validated identity for most sensitive or high-value transactions. Most SSI schemes seems to acknowledge that, in as far as the identities they themselves intend to issue, are usually based on a state identity document. This is the case in IMPULSE, for instance.

[18] ZKPs make it possible to demonstrate the veracity of a given statement (e.g., "the user is over 18 years old", "the user is entitled to drive a car") without sharing the underlying information ordinarily needed to prove the statement (e.g. date of birth, driving license).

SSI are enhanced privacy and security. In part, this likely reflects the more technologically-oriented motivating concerns of many of the developers behind the technical development of SSI. Nevertheless, certain potential economic impacts that SSI could have can be identified. Primarily, these revolve around the possibilities opened up by digital wallets.

The key advantage of digital wallets are the technical characteristics described above: that they allow individuals to collect comparatively fraud-proof digital certificates about all manner of aspects of their lives, store them on a personal device (e.g. a smartphone) where they are instantly available, and seamlessly present them to counterparties online, who in turn can verify them automatically. Moreover, with SSI systems users generally need to master only a single identity/authentication system and process across all the services they use.[19] By contrast, today users often need to manage dozens of separate digital identities and authentication processes, which leads to the problems of abandonment and non-initiation of transactions discussed above. These characteristics give SSI the following anticipated economic impacts:

- *Increased consumption of online services* as digital transactions become easier and faster for users, thus likely lowering rates of abandonment and non-initiation of transactions;
- *Administrative, compliance and computing costs are reduced* for companies and public institutions (the counterparties in online transactions), as verification of credentials can be done automatically and digitally rather than manually and paper-based, and as the counterparty need no longer store so much data about the users (as users store and manage their credentials themselves) (Pignatelli et al. 2019);
- *Reduced fraud and identity theft* due to the greater security VCs offer compared to the manner in which credentials are often presented today (e.g. PDFs of scanned paper documents) (Strüker et al. 2021)
- *Greater interoperability* of identity solutions across ecosystems (Richter and Anke 2021, Stockburger et al. 2021)

It should be stressed that at present, these anticipated impacts are largely hypothetical. SSI schemes remain limited to small-scale or specialised pilots to date, and business models are still at the exploratory stage (European Commission 2020). Building out SSI systems and in particular integrating them into existing IT systems and business ecosystems is likely to often be costly (Doerk et al. 2020). Moreover, while the fact that SSI moves the locus, where user data (certificates) are stored from the service provider to the user's device, promises to increase users' control over their data and reduce the computing, storage and compliance costs of service providers, it also makes the user responsible for the security of their data. However, private users are often relatively poor at managing their own IT security. Moreover, while high quality smartphones are very secure, SSI does introduce a single point of failure – at the limit potentially across *all* of a user's identity-related transaction. Loss or hack of a wallet can thus become a personally devastating and quite costly experience (Doerk 2020).

While one important promise of SSI (or perhaps rather, digital wallets) is that it can increase the volume and variety of digital transactions, sensitive or high-value transactions often require a legally-binding signature. This is true both of private-sector transactions (e.g. a mortgage application) and of public-sector ones (e.g. applying for a permit of some kind). SSI and wallets alone cannot supply these. In other words, realising the full promises of wallets/SSI requires users to have access to an easy-to-use, low-cost or free electronic signature function. Ideally, this should be directly integrated into the identity solution. It is worth noting that in several countries where digital government and the digitisation of the economy were most successful, like Estonia, the government directly subsidised the provision of e-signature solutions to the public (Vassil 2016). Conversely, the fact that in Germany the government did not take comparable measures and acquiring

[19] This is the case also for a system like IMPULSE, where users technically create a separate identity (certificate) for each service they register for with IMPULSE. However, from the user's perspective, each identity is simply differently-labelled icon in the wallet, that they then select to authenticate themselves to the service with. Indeed, in future iterations of IMPULSE, they may not even have to manually select the service-specific certificate (identity) when authenticating – the system may do it automatically. Thus, from the user's perspective, the authentication process is identical for each service.

electronic signature functionality thus remained relatively costly for end-users, is seen as one factor behind the country's slow digitisation ((Felden, et al. 2020).

## 3.3 Implications of the literature for the research questions

The following implications may be derived from the literature for our research questions.

*What are the specific economic effects of using IMPULSE in the pilot cases?*

In summary, the literature suggests that the main effects to be expected from "basic" digital identity systems like the current instantiation of IMPULSE (authentication/log-in only), are limited efficiency gains in the public and/or private sector. In the case of most of the IMPULSE pilot cases, these are likely to be limited to the public sector, as the pilot use cases are in the public sector. Were IMPULSE come to be used more widely (i.e. beyond the current use cases, including in the private sector), there may be an increase in the consumption of public and private digital services, as the substitution of biometrics for traditional authentication technologies like passwords or smartcards removes friction from the transactions.

*How large are the economic effects in the pilot cases likely to be?*

It is helpful to distinguish two impact levels: impact "within" the use case (e.g. "10 percent savings to processing permit X") and economy-wide effects ("1 percent increase to GDP"). The size of "within"-use case effects depend on the specifics of the individual cases, and few ex-ante hypotheses can be derived from the literature. Regarding the size of economy-wide effects however will almost certainly be limited, simply because the use cases are limited. Indeed, the literature suggests that in developed countries, substantial effects are likely only once large numbers of use cases become accessible, and the digital identity solutions include wallet and QES functionalities (which are necessary to enable many of the higher-value use cases).

*Does the use of biometrics for authentication give IMPULSE distinct economic effects, compared to other authentication technologies?*

As noted, it can be surmised that use of biometrics should give IMPULSE distinct economic effects. Biometrics can reduce friction in digital transactions, non-completed transactions, and costs related to lost passwords and similar.

*What economic effects could adding a Digital Wallet and QES functionality to IMPULSE have? What are the economic effects of their current lack in the IMPULSE solution?*

The literature is clear that digital wallets and QES functionality are key to enabling manifold higher-value use cases. As they are missing from the current instantiation, effects observed in the use cases should likely be largely limited to efficiency effects.

*Does being an SSI solution give IMPULSE particular economic effects, that other eID architectures will necessarily lack?*

SSI solutions may increase consumption of digital services by removing friction (e.g. multiple passwords), reduce compliance and admin costs, and improve security and interoperability. However it is unclear whether these effects will show up in the use cases explored here. In particular, since each pilot involves only a single use case, it is unlikely that the particular friction- and interoperability-related effects will be observed, since by definition these can arise only once the same user consumes multiple use cases (services).

# 4 Study of Economic Effects in the different Pilot Cases

The IMPULSE project is trialling the IMPULSE eID solution in six pilots across Europe. They are located in Peshtera in Bulgaria, Aarhus in Denmark, Ertzaintza and Gijon in Spain, Reykjavik in Iceland and in northern Italy (InfoCamere). This section analyses the economic impact of the IMPULSE solution in each pilot. Because the pilot use cases and their larger contexts are quite diverse, the analysis proceeds pilot by pilot.

## 4.1 Method

To understand the possible economic impacts of IMPULSE in the pilots, we proceeded as follows. We first studied various documentary materials about the pilots supplied by the consortium partners running the pilots (the "case owners"), and then conducted a semi-structured interview with each case owner in Spring-Summer 2022. A list of interviewees is included in Appendix 1. Each interview partner was asked a common set of questions (with some case-specific adjustments), with non-scripted follow-up questions as new themes emerged in the conversation. Questions focused on how the service, in which IMPULSE was to be deployed, was currently provided and identity authenticated; how using IMPULSE would change the process of service delivery and authentication for users (citizens) and public authorities, and what benefits but also drawbacks the interviewees expected from using IMPULSE, for both the citizens and the public administrations. As much as possible, we sought to quantify the benefits/costs of IMPULSE already during the interview. Possible obstacles to using IMPULSE were also covered. A questionnaire is included in Appendix 2. The interviews were recorded and analysed, with further follow-up questions by email or telephone, where needed. On the basis of the information thus collected, quantitative models were built to estimate impacts. Further data for the models was then collected from the case owners via questionnaires and email.

## 4.2 Results

### 4.2.1 Municipality of Peshtera, Bulgarian

#### 4.2.1.1 Description of the Pilot Use Case[20]

The Bulgarian Use Case involves using IMPULSE for authentication when citizens apply for a Certificate of Permanent Address ("certificate"). Citizens must obtain this certificate in various circumstances; e.g. when renewing their state identity card, when buying or selling real estate, and if they move (change address).

Since January 2021, when the Municipality of Peshtera (MOP) launched a digital services platform, citizens have been able to obtain the certificate digitally. However, this digital path is hardly used. Instead, most citizens still go to the municipal offices to get the document in person. This face-to-face (F2F) path creates additional work for civil servants. Were citizens to use the digital path, civil servant workloads could be reduced, and citizens also save time. The F2F path also tends to lead to larger queues in the municipal offices, which was seen as a health risk during the pandemic.

The staff from MOP believe that a key reason for why citizens have not used the digital path more to date, is that it requires them to first obtain a digital identity with QES functionality from one of the recognised Bulgarian digital identity providers. According to MOP staff, this is time-intensive (travel to another city, queue at the offices of the ID provider etc.) and costly (fees for the ID and QES service). Moreover existing eID solutions are not always well-adapted for mobile and/or require the use of additional hardware and passwords. The advantage of IMPULSE, in their view, is that the registration process is significantly faster and easier for citizens, since they can sign up for IMPULSE at home without needing to visit a dedicated office. It may also be cheaper (but see discussion below), and does not require the use of a desktop computer. In summary, the main economic effect expected from IMPULSE for civil servants and citizens are time/labour savings, as well as potentially lower expenses for other items (e.g. postage, hardware).

#### 4.2.1.2 Estimate of the economic impact

Table 1 lays out the steps and time required to obtain a Certificate of Permanent Address via the F2F path, and via the digital path with existing eID solutions and with IMPULSE, for both citizens and civil servants.[21] As can be seen, the amount of time required of citizens and civil servants to issue a certificate varies considerably by path. Using the F2F path, it takes the citizen between ~82 and ~210 minutes, and the civil servant ~35 to ~40 minutes. Using the digital path with existing eID solutions costs the citizen ~118 minutes including the

[20] The following description is based on our interview and follow-up discussions with MOP staff.
[21] The estimates for the time required for the different steps are based on our interview and follow-up discussions with MOP staff, as well as desktop research.

initial onboarding to obtain the digital ID (~24 minutes if the ID has already been obtained); the civil servant ~31 minutes. Using IMPULSE, the time cost to the citizen is reduced to ~27-30 minutes (including onboarding; otherwise ~24 minutes); the time cost for the civil servant remains at ~31 minutes. In other words, eIDs and IMPULSE in particular offer citizens real time-savings compared to F2F (between ~53 and ~183 minutes saved), while also offering the civil servants smaller time savings (~5 to ~9 minutes). Compared to existing eID solutions, IMPULSE offers citizens significant one-off time savings due to its simpler onboarding process, as this does not require travel (~89-92 minutes saved). Table 2 summarises the time savings with IMPULSE.

Time savings have a monetary value. This is obvious in the case of working time (e.g. here of civil servants). But it applies also to the "free" time of citizens. This follows the double intuition that (i) people attach an at least implicit monetary value to their free time (they could work otherwise), and (ii) that in practice, time devoted to e.g. administrative errands like getting a state certificate, may come at the expense of working time. To calculate the monetary value of the civil servant time savings, we use the average hourly wage for the public administration and defence sectors, as reported by the National Statistical Institute of Bulgaria (NSIB 2022). For the value of the citizens' time, we use the average hourly wage (all sectors) (NSIB 2022).[22] However, for both groups the monetary value of the time saved is small: BGN 10 to BGN 34 for citizens (the equivalent of about one to three hours work at average wage levels), and between BGN 0.8 and 1.6 for civil servants (the value of a few minutes' work at average civil servant wage levels). The results are summarised in Table 2.

There are also direct monetary savings. Excluding travel costs (counted here only in terms of time spent), the IMPULSE system offers citizens at least two further sources of monetary savings. The first is costs for postage or curriers in the F2F path (BGN 1.8 and BGN 6 respectively, borne by citizens), if citizens do not pick up the issued certificate at the municipal offices in person. The second is cost for hardware. The existing Bulgarian eID schemes (e.g. that of BTrust) require the user to purchase a hardware reader system (currently priced at BGN 21). This cost falls away when using IMPULSE.[23] The annual value of these savings are presented in Table 2, assuming a 10-year lifespan of a reader device (i.e., BGN 2,1 = BGN 21 / 10).

Tables 1 and 2 presented the time and monetary savings from using IMPULSE for issuing a single certificate. How great could the *aggregate* savings for the municipality and citizens of Peshtera be, if IMPULSE were widely used? To calculate this, we need to multiply the number of certificates issued annually with the savings described in Table 2, adjusted by the foreseeable adoption rate of IMPULSE.

The Certificate of Address is not the only certificate issued by MOP for which the IMPULSE digital path could be used. Other certificates for which IMPULSE could be used are that of Current Address, of Marital Status, and of Name Change. Table 3 shows the number these certificates issued by MOP for each year since 2019.

According to MOP, 97 percent of certificates are currently issued via the F2F path (with 94 percent being picked up in person by the citizens); only 3 percent are currently issued digitally. Partly, this may reflect the digital path's novelty. It only became operational in January 2021; many citizens may still not know about it, and/or lack an eID. Indeed, at 27 percent in 2021 (EuroStat 2023), the share of Bulgarians who have "used the internet" for some form of "interaction with public authorities" is considerably higher than the share who have used the digital path in Peshtera for certificates. Notably, the number of Bulgarians, who have used the internet to "interact with the authorities" in general, has been steadily rising (in 2015 it was 18 percent), suggesting that people are in general open to digital services provided by the government. Available data for smartphone ownership in Bulgaria, shows rapid increases.[24]

[22] Using the average public sector wage for the civil servant calculations is reasonable, as MOP staff told us that in practice, there can be considerable variation as to the staff (and pay grade) who provide F2F services to citizens.
[23] Existing Bulgarian eID systems also charge users an annual subscription fee. We do not count this as a saving, since IMPULSE may also charge users some form of fee. While IMPULSE is still too far from commercialisation for us to be able to say how it may be monetised and what fee/charging structures might be, it is reasonable to assume that IMPULSE could at least not charge *more* than competing systems.
[24] The only available empirical data is for 2014 – 2016. In this period, smartphone penetration (defined as ownership plus a minimum monthly usage) jumped from 30 percent to 48 percent (Statista 2017). It is reasonable to assume that penetration has escalated since.

| Step | Face to Face Path | | | Digital Path – using existing eID solutions | | | Digital Path – using IMPULSE | | | Comments and Assumptions |
|---|---|---|---|---|---|---|---|---|---|---|
| | *Description of Step* | *Time Citizen* | *Time Civil Servant* | *Description of Step* | *Time Citizen* | *Time Civil Servant* | *Description of Step* | *Time Citizen* | *Time Civil Servant* | |
| *Obtaining a Digital Identity* | | | | | | | | | | |
| 1 A | NA | | | Access Website, fill out forms | 2 Min | | Onboarding to IMPULSE | 3-5 Min | | |
| 1 B | | | | Travel to Office of Service Provider | 30 Min | | | | | Nearest office is Pazardzhik; 24 Min. travel time by car (Google Maps); we add 6 Min. for parking etc. |
| 1 C | | | | Wait to be served | 5 Min | | | | | |
| 1 D | | | | Present ID card, fill out further forms | 7 Min | | | | | We measured the time required to fill out the forms |
| 1 E | | | | Return travel | 30 Min | | | | | |
| 1 F | | | | Install reader hardware and software on home computer | 20 Min | | | | | |
| *Applying for the Certificate of Permanent Address* | | | | | | | | | | |
| 2 A | Travel to Municipal Office | 10-15 Min | | Access MOP website | 1 Min | | Access MOP website | 1 Min | | |
| 2 B | Wait for turn | 15-120 Min | | Select & complete form | 20 Min | | Select & complete form | 20 Min | | |
| 2 C | Speak to civil servant, state purpose, receive application form | 2 Min | 2 Min | Clarify open questions (FAQ page, etc.) | 1-1.4 Min | | | 1-1.4 Min | | Every 5th citizen using Digital Path needs extra 5-7 Min to look up information. |
| 2 D | Complete form | 20 Min | | Upload completed form | 1 Min | | | 1 Min | | |
| 2 E | Ask Civil Servant clarifying questions | 0.24-0,36 Min | 0.24-0,36 Min | | | | | | | F2F: every 5th citizen has questions taking 2-3 Min. |
| 2 F | Return form, show ID card, pay fees | 2 Min | 2 Min | | | | | | | |
| 2 G | Return travel (citizen) | 10-15 Min | | | | | | | | |
| 2 H | Civil servant processes forms, creates Certificate | | 30 Min | | | 30 Min | | | 30 Min | |

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| Step | Face to Face Path | | | Digital – existing eID solutions | | | Digital – IMPULSE | | | Comments and Assumptions |
|---|---|---|---|---|---|---|---|---|---|---|
| | *Description of Step* | *Time Citizen* | *Time Civil Servant* | *Description of Step* | *Time Citizen* | *Time Civil Servant* | *Description of Step* | *Time Citizen* | *Time Civil Servant* | |
| | *Receiving the completed Certificate of Permanent Address* | | | | | | | | | |
| | *Option 1: Pick up by Citizen at Municipal Offices* | | | *Certificate sent to Citizen by email, or uploaded to a secure electronic platform* | | | *Certificate sent to Citizen by email, or uploaded to a secure electronic platform* | | | |
| 3 A | Citizen travels to Municipal Offices | 10-15 Min | | Certificate sent to citizen by email or uploaded to electronic platform | | 1 Min | Certificate sent to citizen by email or uploaded to electronic platform | | 1 Min | |
| 3 B | Citizen gets certificate from civil servant | 3-5 Min | 3-5 Min | Citizen gets certificate from email or platform | 1 Min | | Citizen gets certificate from email or platform | 1 Min | | |
| 3 C | Return travel (citizen) | 10-15 Min | | | | | | | | |
| | *Option 2: Certificate of Address is sent by Post to Citizen* | | | | | | | | | |
| 4 A | Civil servant prepares & sends citizen letter with Certificate | | 2 Min | | | | | | | |
| | *Option 3: Certificate of Address is sent by Currier to Citizen* | | | | | | | | | |
| 5 A | Civil servant prepares & sends citizen letter with Certificate | | 2 Min | | | | | | | |
| | *Options 4: Certificate sent to Citizen by email, or uploaded to a secure electronic platform* | | | | | | | | | |
| 6 A | Civil servant sends certificate to citizen by email or uploads it to secure electronic platform | | 1 Min | | | | | | | |
| 6 B | Citizen gets certificate from email or platform | 1 Min | | | | | | | | |
| **Total Time Required** | | | | | | | | | | |
| **F2F Path** | | 82.24 – 209.36 Min | 35.24 - 39.36 Min | **Existing Digital Path (incl. obtaining eID)** | 118 – 118.4 Min | 31 Min | **IMPULSE Path (incl. obtaining eID)** | 27 – 29.4 Min | 31 Min | |

**Table 1: Steps required to obtain a Certificate of Permanent Address in different Paths**

| Item | | Savings to Citizen *per certificate* | | Savings to Civil Service *per certificate* | |
|---|---|---|---|---|---|
| ***Savings from IMPULSE vs F2F*** | | ***Lower Bound*** | ***Higher Bound*** | ***Lower Bound*** | ***Higher Bound*** |
| Time saved | (Minutes) | 52,8 | 182,4 | 4,3 | 8,4 |
| Monetary value of time saved | (BGN) | 9,8 | 34 | 0,8 | 1,6 |
| Postage savings (if post used) | (BGN) | 1,8 | 1,8 | | |
| Currier savings (if currier used) | (BGN) | 6 | 6 | | |
| ***Savings from IMPULSE vs. existing eID solutions*** | | | | | |
| Time saved incl. onboarding | (Minutes) | 88,6 | 91,4 | | |
| Time saved excl. onboarding | (Minutes) | | | | |
| Monetary value of time saved (in. onboarding) (BGN) | | 6,7 | 7,0 | | |
| Monetary value of time saved (ex. onboarding) (BGN) | | | | | |
| Hardware savings (annual, over 10 years) (BGN) | | 2,1 | 2,1 | | |

**Table 2: Time and monetary savings from using IMPULSE compared F2F and existing eID solutions**

| Certificate Type | 2019 | 2020 | 2021 | *Average* |
|---|---|---|---|---|
| **Certificates of Permanent Address** | 127 | 183 | 167 | *159* |
| **Certificates of Current Address** | 268 | 293 | 317 | *293* |
| **Certificate of Marital status** | 287 | 317 | 268 | *291* |
| **Certificate Name Change** | 137 | 97 | 119 | *118* |
| **All Certificates** | **819** | **890** | **871** | ***860*** |

**Table 3: Number of Certificates issued annually by MOP**

The experience of Estonia indicates that mass adoption of digital government services can follow an exponential curve, with a slow start followed by a rapid take-off after several years (Vassil 2016) – in other words, a typical S-curve known also from other technologies (Rogers 2003 [1962]). Nevertheless, a 100 percent adoption rate is unrealistic. As of 2021, even in highly digitalised countries like Sweden, Denmark and Estonia, only between 82 percent (Estonia) and 90 and 92 percent (Sweden and Denmark) had "used the internet for interaction with public authorities" (EuroStat 2023). We therefore calculate two multi-year adoption scenarios: a baseline scenario and ambitious scenario. In the subsequent economic estimations, we compare these two scenarios to a continuation of the status (97% of certificates issued F2F).

**This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004459**

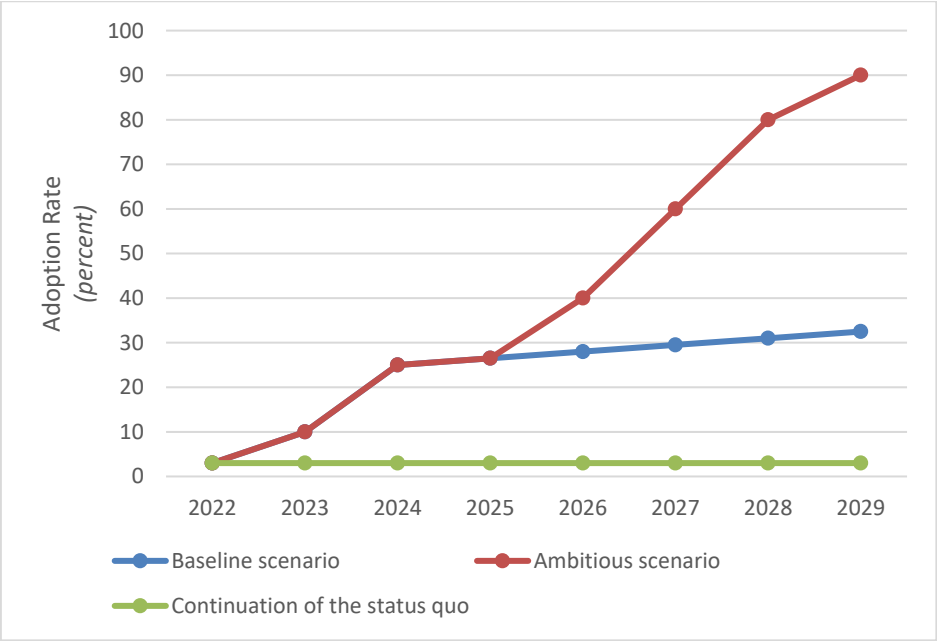


**Figure 1: Adoption Scenarios for Peshtera**

In the baseline scenario, usage of IMPULSE first grows rapidly, to 25 percent of people applying for certificates by 2024 using IMPULSE, as the most digitally-open section of the population – who may already use the internet for interactions with the public authorities, begin using IMPULSE. We assume growth to 25 percent rather than the 27 percent reported in the Eurostat data, to take account of the fact that Peshtera is a more rural area. Thereafter though growth of the IMPULSE user base slows to 1.5 percent annually – the average rate at which internet use for interactions with public authorities grew historically according to Eurostat. In the ambitious scenario, growth does not level off, but accelerates to 40% in 2026 and 80% in 2028. These may seem like extreme figures, but if anything they are more conservative than the increases seen in Estonia once the "take-off" stage was reached (cf. Figure 3 in Vassil 2016).

Figures 2-4 show how many certificates are issued via the F2F and the digital (IMPULSE) path, respectively, under the two scenarios (Figures 3 and 4), and under a continuation of the status quo (Figure 2). For all calculations, we assume that the same average number of certificates is issued yearly as between 2019 and 2021 (860 certificates a year).

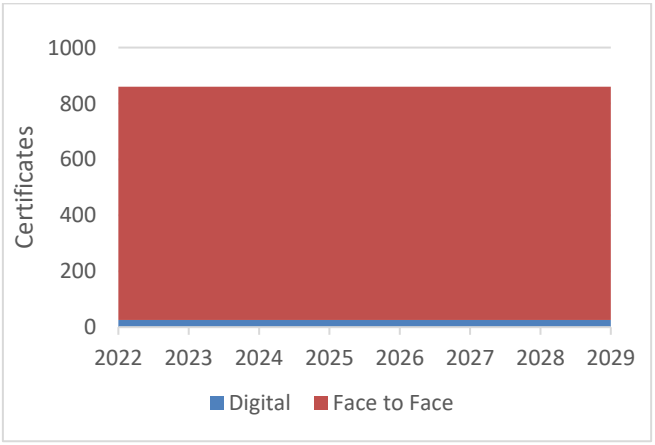


**Figure 2: Certificates issued – status quo**

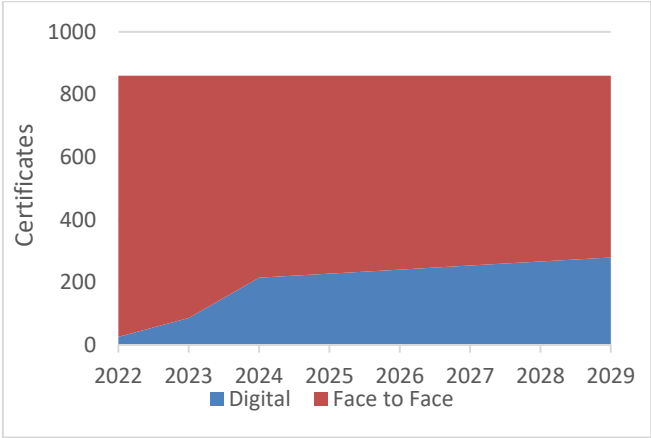


**Figure 3: Certificates issued – baseline scenario**

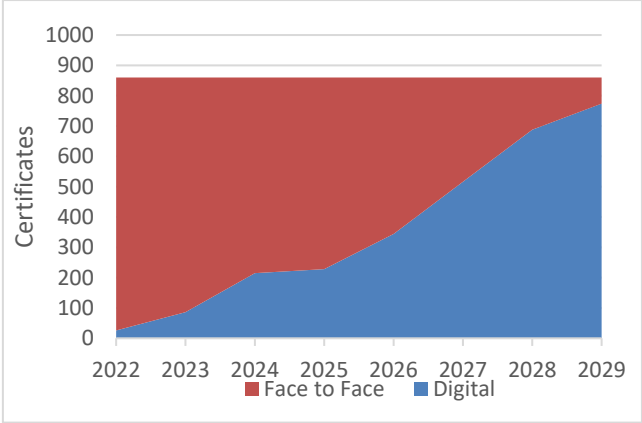


**Figure 4: Certificates issued – ambitious scenario**

To calculate the annual monetary and time savings for citizens and civil servants from using IMPULSE, we multiply the number of certificates issued annually through the F2F and the digital path (IMPULSE) under each scenario, with the time required per certificate of citizens and civil servants in each path. We then subtract the total time required of citizens (civil servants) in the "baseline" and "ambitious" scenarios from the continuation of the status quo scenario. The difference is the annual savings. To calculate monetary savings for citizens, we multiply the results with the average hourly wage (all sectors). For civil servants, we use the average hourly public-sector wage.[25]

As noted above, the time required of both civil servants and citizens to issue a certificate can vary considerably within the same path, depending on vagaries like travel or queuing time. In Table 1, we therefore often gave time ranges. On this basis, in our estimates, we calculated high and low bounds for the annual time and monetary savings. However, for sake of ease of exposition, here we only show an average annual savings (the average of the high and the low bound figure).

Figures 5 and 6 shows the annual time and monetary savings citizens can expect in the "baseline" and the "ambitious" scenario vs the status quo. Figures 7 and 8 show this for civil servants

[25] We use the October 2022 wage figures reported by NSIB. Because of the currently very high inflation rate in Bulgaria, we apply a one-time 20 percent increase to all wage figures after 2024. This is in line with the 20 percent increase in the minimum wage level enacted in Bulgaria in late 2022, on account of the inflation levels.

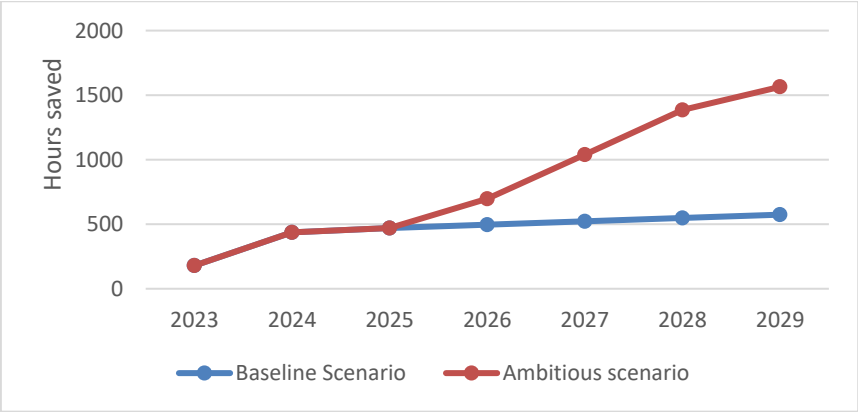


**Figure 5: Hours saved by citizens with IMPULSE vs. status quo**

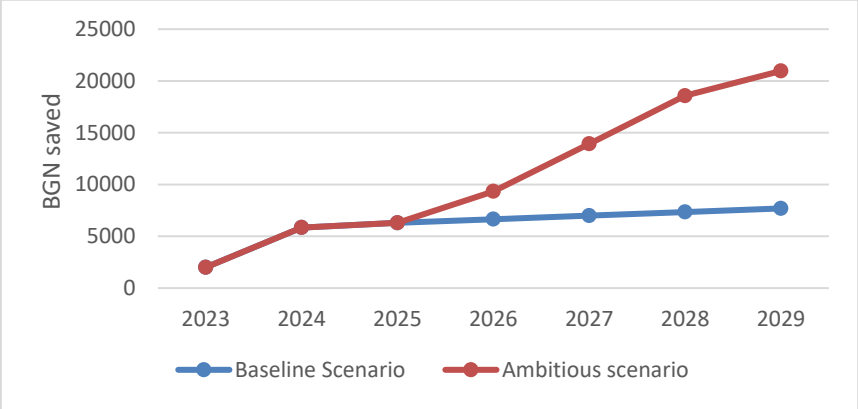


**Figure 6: Citizens' monetary savings with IMPULSE vs. status quo**

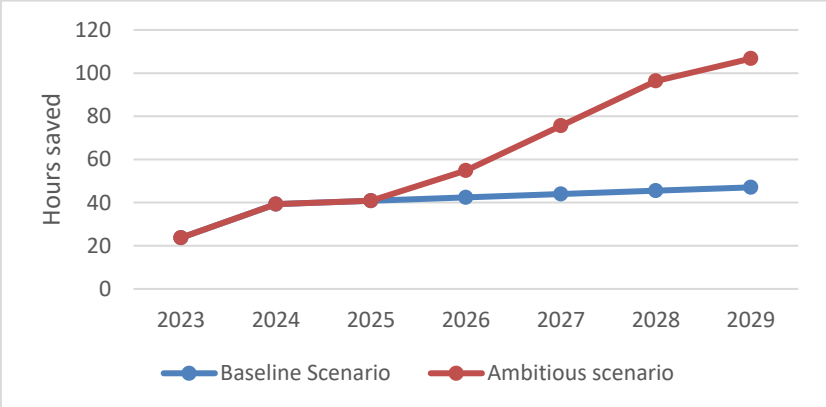


**Figure 7: Civil servants' time savings with IMPULSE vs. status quo**

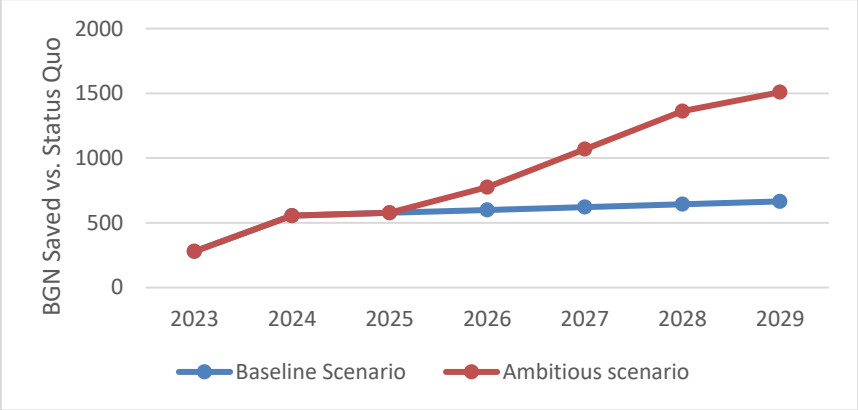


**Figure 8: Civil servants' monetary savings with IMPULSE vs status quo**

As can be seen the savings both to citizens and to the municipality are ultimately quite limited. Even in the ambitious scenario, in 2029, where 90 percent adoption rate is reached and the greatest annual savings are made, citizens only save about 1564 hours, or around 1.8 hours per certificate. Likewise, the civil service of MOP saves only around 107 hours, or BGN 1509, in 2029 Over ten years (2023 – 2032), total savings for the civil service might approach BGN ~10,600 (ambitious scenario); though in the baseline scenario they remain as low as BGN ~6000.[26]

Counter-intuitively, this should not be seen as a reason not to further pursue digital government and build appropriate eID systems like IMPULSE. Rather, the implication is that digital government, and systems like IMPULSE, will only start to make economic sense once they are used across large numbers of public and private use-cases. Small-scale savings, such as those produced by this particular use case in this municipality, can add up once many such savings come together.

### 4.2.2 Aarhus Case, Denmark

#### 4.2.2.1 Description of the Pilot Use Case[27]

The Aarhus Pilot involves deploying the IMPULSE eID and facial recognition technology on lockers for the residents of homeless shelters in Aarhus. The lockers are to provide the shelter residents with a safe place to store small valuables and documents, in particular their NemID cards. NemID is the main identity scheme used in Denmark. Without it, it is difficult to apply for social services or take part in most fields of social, economic and political life. For homeless people, however, keeping their NemID safe can be challenging. According to the Aarhus municipal staff involved in the Pilot, the cards are frequently lost. This has two unfortunate consequences: shelter residents go without services they would otherwise be entitled to, and/or social services staff (as well as others, e.g. parish clerks, see below) become burdened with additional work, as the shelter residents often turn to them to help them apply for a new NemID card. This usually occurs at the monthly "social services clinic", which Aarhus social services staff run at the homeless shelters. It is hoped that by providing shelter residents with the lockers, the number of lost NemID cards can be significantly reduced. The lockers will also relieve shelter of the burden of being asked by shelter residents whether they could store their NemID cards on their behalf, something that may be a challenge for the staff to refuse, but is technically illegal.

#### 4.2.2.2 Economic impact estimate

The main direct *economic* impact expected in the pilot is efficiency savings (labour time and cost) for the individuals involved in helping shelter residents to reapply for NemID cards. According to Aarhus staff,

[26] Calculating time savings over 10 years and their implicit monetary value for citizens is a rather theoretical exercise. How meaningful, to a citizen, is the information that over 10 years, she might save, say, 18 hours, with an implicit value of BGN ~200? However, the equivalent values for citizens would be a total of 10464 hours saved over 10 years in the ambitious scenario, valued at ~140,000 BGN.

[27] The following description is based on our interview and follow-up discussions with Aarhus municipal staff.

reapplying for a NemID card generally involves the following steps, described in Table 4. The labour and material costs are presented in Table 5.[28]

| Step | Description of Step | Time required | | | | |
|---|---|---|---|---|---|---|
| | | *Shelter Resident* | *Parish Clerk* | *Social Service Staff* | *NETS Staff* | *Shelter Staff* |
| **1** | Shelter resident goes to parish church to obtain his/her birth certificate. Travel is by foot; travel time ~10 Min. each way. | 60 Min. | 40 Min. | | | |
| **2** | Attend one of the monthly social services clinics run by Aarhus municipality social service at the shelter, who help the resident reapply for a NemID card. ~30 Min. waiting time assumed | 60 Min. | | 30 Min. | | |
| **3** | Nets DanID Company issues new NemID card, which is posted to shelter | | | | 15 Min.[29] | |
| **4** | Resident receives post with new NemID card | 1 Min. | | | | 2 Min. |
| ***Total time required*** | | *121 Min.* | *40 Min.* | *30 Min.* | *15 Min.* | *2 Min.* |

**Table 4: Steps required to obtain a new NemID card for shelter residents**

| Item | Cost (DKK) |
|---|---|
| **Shelter resident** ***monetary value of time*** | -- (see Fn. 28) |
| **Parish clerk** ***hourly wage***[30] | 230,65[31] |
| **Social services staff** *hourly wage* | 212,38[32] |
| **NETS DanID staff** *hourly wage* | 179,9[33] |
| **Shelter staff** *hourly wage* | 213,71[34] |
| **Material cost of card** | 4,1[35] |
| **Postage** (registered letter) | 96[36] |

**Table 5: Labour, material and postage costs**

[28] Perhaps controversially, we do not estimate the monetary value of the shelter residents' time. Because the residents are generally unemployed and living on the margin of society, it is difficult to come up with a useful proxy. For example, since they are not participating in the labour force – and likely do not have the option of doing so, at least in the short term – hourly wages are not a meaningful proxy. At the same time, we do not wish to imply that these individuals' time is "worthless". Hence we also do *not* estimate its value as zero, but simply do not estimate it.

[29] This number is our best guess, based on consultations of the literature and expert conversations. Efforts to contact Nets DanID A/S proved unfortunately unsuccessful.

[30] All hourly wages calculated from monthly wage data referenced in the following footnotes, assuming 22 working days a month and a 7,4 hour day (37 hour week).

[31] https://www.ug.dk/job/job-fordelt-paa-erhvervsomraader/paedagogiskkirkeligtogsocialtarbejde/kirkearb/kordegn-job

[32] https://www.ug.dk/job/job-fordelt-paa-erhvervsomraader/kontorregnskabfinans/kontorsekretaerarb/assistent-i-det-offentlige

[33] https://www.ug.dk/job/job-fordelt-paa-erhvervsomraader/kontorregnskabfinans/kontorsekretaerarb/kontormedarbejder-job, "Office Clerk in private sector". Note that the salary listed at ug.dk corresponded quite well to two salaries given for "customer representative" at Nets DanID on Glassdoor.com

[34] https://www.ug.dk/job/job-fordelt-paa-erhvervsomraader/paedagogiskkirkeligtogsocialtarbejde/socraadgivning/socialraadgiver-job

[35] Taken from OECD Cost of Doing Business data (https://archive.doingbusiness.org/en/data/exploreeconomies/denmark)

[36] https://www.postnord.dk/en/tools/postage-calculator

The total cost of reissuing a NemID card to one of the shelter residents would thus equal to:

$$Cost_{Card} = W_{Clerk} * T_{Clerk} + W_{Service\_Staff} * T_{Service\_Staff} + W_{Nets\_Staff} * T_{Nets\_Staff} + W_{Shelter\_Staff} * T_{Shelter\_Staff} + M + P$$

where W is the hourly wage, T the time required per card reissuance and M and P the material and postage costs respectively. Adding in the numbers from Tables 4 and 5, the cost per card is thus 412.16 DKK.

The total homeless population in Aarhus numbered 507 individuals as of 2022.[37] The shelter staff estimate that about 30 to 50 percent of the shelter residents they come into contact with, no longer possess a NemID card. Thus, we may estimate that between ~151 and ~254 of the homeless in Aarhus have no NemID. Of course, not all these people are trying to get NemID cards reissued. On the contrary, the social services' staff who run the clinics estimate that each month, between 1 and 4 individuals come to them for help with card reissuance, so about ~12 to ~48 individuals a year. This would imply a total cost of between ~6565 DKK and ~19,784 DKK in 2022.[38] Of that, between ~2561 DKK and ~10,244 DKK are costs directly borne by the municipality[39] (cf. Table 6).

Homelessness in Aarhus has fallen considerably in recent years. In 2017, there were still 767 homeless in Aarhus; on average, between 2015 and 2022, there were about 673 homeless.[40] Applying the same ratios of cardless-to-homeless population and homeless-to-card reissuance as observed in 2022, that would translate to ~202 to ~337 homeless without NemID cards, and between ~16 and ~64 cards reissued to homeless people via the help of the social services staff in the monthly clinics every year.[41] This implies average total costs of between ~6565 DKK and ~26,261 DKK, of which between ~4,440 and ~13,600 DDK would have been borne directly by the municipality (Table 6).

| | **2022** *lower bound* | **2022** *upper bound* | **2015–22 Average** *lower bound* | **2015–22 Average** *upper bound* |
|---|---|---|---|---|
| **Cards reissued per year** | 12 | 48 | 16 | 64 |
| **Total cost of card reissuance** | 6565 DKK | 19,784 DKK | 10,244 DKK | 26,261 DKK |
| **Direct cost to the municipality** | 2561 DKK | 10,244 DKK | 4400 DKK | 13,600 DKK |

**Table 6: Annual number and costs of NemID card reissuance in Aarhus**

How great might savings realistically be? It is hard to imagine that even with lockers, no NemID card would be lost anymore. We model three scenarios, with losses falling by 30, 50 and 80 percent. Because the development of the homeless population is hard to foresee, we use the data for the period 2015 – 2022, rather than simply projecting the (lower) 2022 figure forward. To simplify the data presentation, instead of working with a ranged number of reissued card each year (e.g. 16 to 64), we assume that on average, 40 cards are reissued (status quo baseline).[42] Figures 9-11 present the results: Compared to the Status Quo, and depending

[37] https://www.aarhus.dk/nyt/sociale-forhold-og-beskaeftigelse/msb-2022/september-2022/investeringer-i-bolig-stoette-og-faellesskaber-hjaelper-unge-ud-af-hjemloeshed/

[38] The formula is $Cost_{Card}*12$ for the lower bound, and $Cost_{Card}*48$ for the higher bound.

[39] We assume that the salaries for social services' and shelter staff as well as postage and material costs are borne directly by the municipality.

[40] https://www.vive.dk/da/udgivelser/hjemloeshed-i-danmark-2022-18153/

[41] We arrive at these figures through the following calculations:
(1) we know that in 2022 Aarhus had 507 homeless, and between 1 and 4 cards were reissued each month (12-48 over the entire year).
(2) We calculate the ratios of annual card-reissuance-to-homeless for each of these two bounds; 12/507=0,024 (lower bound) and 48/507=0,095 (upper bound)
(3) We multiply these ratios with the average number of homeless in the years 2015-22 (673), to get the lower and the upper bounds of the number of cards reissued annually, on average (16 and 64)

[42] We arrive at this number as follows:
(1) We know that in 2022, between 1 and 4 cards were reissued each month
(2) We assumed an equal distribution of the four reissue values (1, 2, 3, 4) across the twelve months of the year. I.e., for three months, 1 card was reissued each months; for the next three months, 2 cards were reissued each month, etc.
(3) 3*1 + 3*2 + 3*3 + 3*4 = 30 cards reissued across all of 2022.
(4) Following the procedure described in Fn. 41, we now calculate the cards-reissued-to-homeless population

on scenario, this produces total annual savings between 4946 DKK (30 percent reduction in card reissuance) and 13,189 DKK (80 percent reduction) would be saved. Direct municipal savings range from 2561 DKK to 6829 DKK.

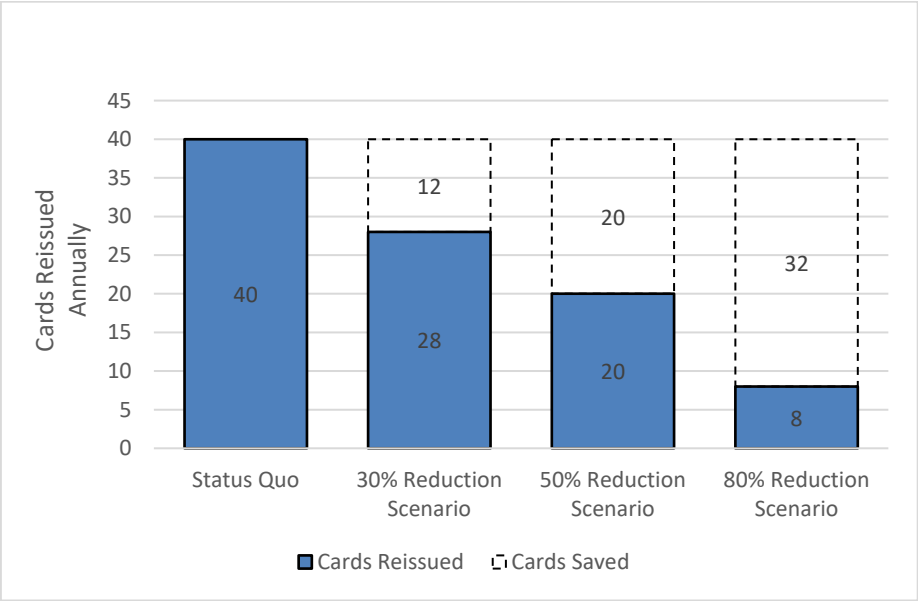


**Figure 9: Cards reissued/saved under different scenarios**

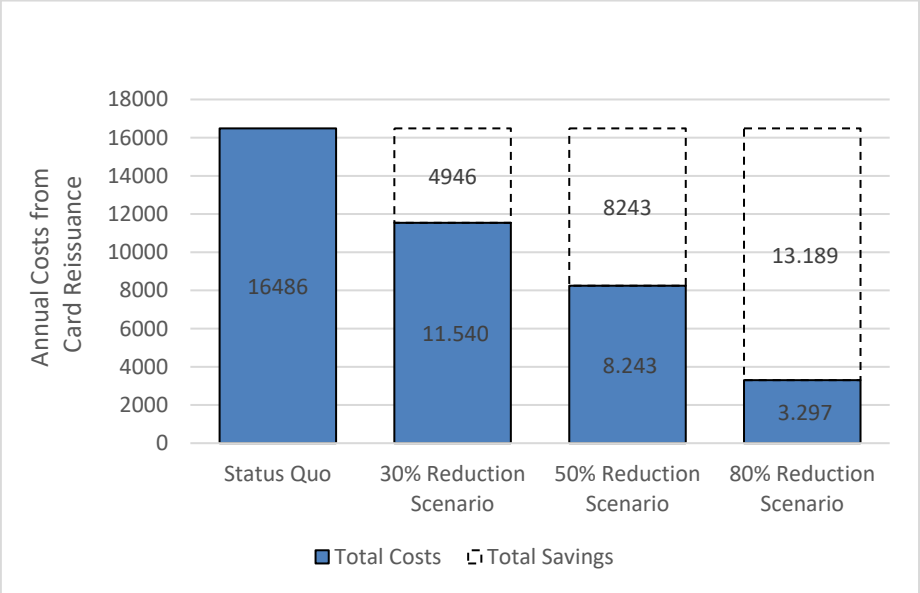


**Figure 10: Total cost savings under different scenarios**

(30/507=0,59) for 2022, and then multiply this ratio with the 2015-22 average homeless population (673), to arrive at 40 cards reissued on average each year in that period (673*0,59 = ~40).

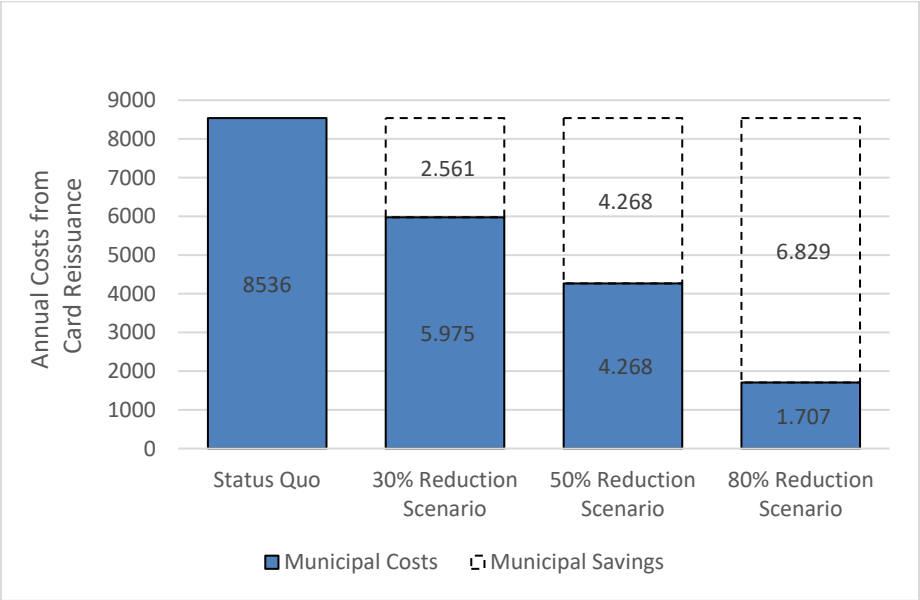


**Figure 11: Municipal cost savings under different scenarios**

The bottom line is that direct economic savings from the installation of the lockers are quite limited. Indeed, the (gross) savings calculated above also need to be put against the cost of the lockers. According to Aarhus social services staff, about 5 to 6 lockers would be needed to provide all Aarhus shelter residents with a personal locker drawer. Little data is available on the cost of purchasing, installing and maintaining the lockers, but from the above savings we can calculate what the maximum permissible locker cost would be, if the municipality is to at least break even. We assume a life span of 10 years for the locker. According to our scenarios, over ten years, direct municipal savings could range between 25,610 and 68,290 DKK (~3,445–9,180 EUR). An examination of lockers on offer at Amazon.com suggests that basic multi-drawer metal lockers are likely to cost at least ~200€ a piece (~1500 DKK). 6 Lockers would thus run to ~9000 DKK initial purchase cost. Assuming installation and maintenance are performed by a local-government janitor, that installation time per locker is one hour and it receives 1 hour of maintenance per year, maintenance and installation costs would equal to ~11,000 DKK over ten years.[43] Purchase, installation and maintenance costs would thus equal ~20,000 DKK over ten years, or between ~30 percent and ~80 percent of the total municipal savings expected over ten years, depending on scenario.

It should be stressed that this does *not* yet include the costs for software service and maintenance, which are likely to be non-trivial. In summary, net savings are likely to be small at best. It should be noted that the costs for initial software development and integration – which are substantial, at ~150,000 DKK according to Aarhus staff – are *not* included in these estimates, as they are largely financed through the IMPULSE project. Were they included, savings would almost certainly turn negative. As the cost/savings calculations made above largely focus on *variable* costs per locker, it is unlikely that the basic picture would change much, were the locker system for instance to be installed also in other Danish cities with substantial homeless populations (e.g. Copenhagen). While gross saving would of course rise, (variable) costs would too, thus leaving the net savings picture largely unchanged.

A further benefit expected from the introduction of IMPULSE-enabled lockers and the (hoped-for) reduction in lost NemID cards, are time savings for the social services staff (as well as parish clerks), who currently need to devote part of their working time to helping shelter residents reapply for new cards. Time savings for these workers might constitute a net benefit for the municipality, even without overall monetary savings. For example, they might now be able to perform valuable work and thus raise the quality of social services overall. How large might these time savings be?

[43] We assume an average hourly wage of a janitor of DKK 168, in line with https://www.ug.dk/job/job-fordelt-paa-erhvervsomraader/rengoeringejdservicerenovation/ejdservicearb/ejendomsfunktionaer-job

As noted above, social services staff spend about 30 minutes per lost and reissued NemID card, while parish clerks spend about 40 minutes. Our scenarios project that between 12 and 32 fewer cards would be lost and reissued annually if the IMPULSE lockers are introduced. Figure 12 shows the expected time savings for both. As can be seen, these two are fairly small. Social services' staff would save between 6 and 16 hours annually, while parish clerks would save around 8 to 21 hours – or roughly 1 to 3 working days a year.

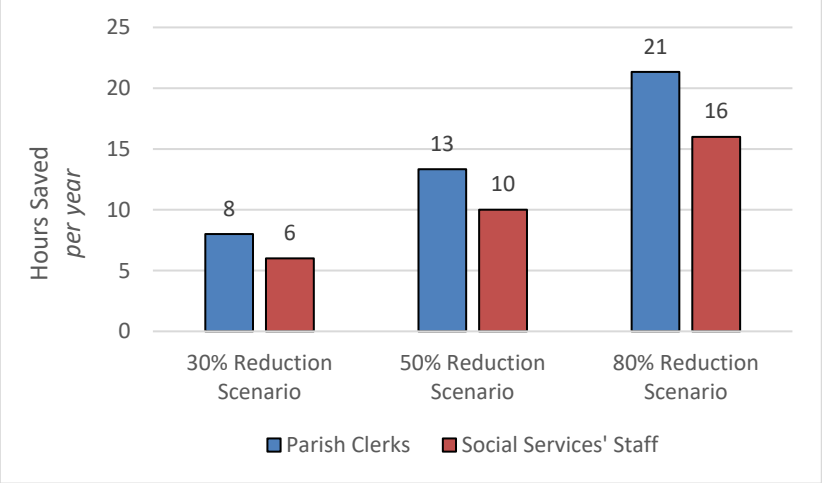


**Figure 12: Time savings under different scenarios**

Not shown in Figure 12 are the time savings for the shelter residents. Getting a card reissued takes about 2 hours of a resident's time. The total time savings for the residents as a group would thus range between 24 and 64 hours a year.

While this analysis thus finds no strong *economic* case for installing the IMPULSE-enabled lockers in Aarhus, this does *not* mean that they should not be installed. On the contrary, provision of the lockers may have a number of important of social benefits. These include facilitating the re-integration of shelter residents into regular social and economic life by reducing the number of "cardless" individuals, and reducing moral pressure on shelter staff to engage in what is an illegal activity (storing NemID cards for residents). It would also offer social services' staff and parish clerks a modest time saving.

### 4.2.3 Ertzaintza Case, Spain

#### 4.2.3.1 Description of the Pilot Use Case[44]

The Ertzaintza pilot use case involves the further development of an existing system for the digital submission of criminal complaints in the Basque region. Traditionally, people who want to file a criminal complaint had to do so in person (F2F) at a police station. For some years now, Ertzaintza, the Basque law enforcement (police) agency, has allowed people to submit complaints about minor crimes[45] through an online form. However, they still need to go the police station afterwards, to sign the complaint in person, within 72 hour. Otherwise, the complaint is considered invalid and discarded.

The intention in the IMPULSE Pilot is to enable people to lodge complaints entirely online (i.e., without having to appear at the police station to sign the complaint in person afterwards). Discussions with Ertzaintza staff revealed three main expected benefits from this:

- Time and cost savings for the Ertzaintza police officers
- Time and cost savings for the citizens lodging complaints
- Making it easier for citizens to file complaints, thus reducing the number of unreported crimes

[44] The following description is based on our interview and follow-up discussions with Ertzaintza staff.
[45] Such as petty thefts, vandalism and administrative infringements.

At the same time, there are also uncertainties over whether the use of IMPULSE really would have these benefits. Indeed, there is concern that IMPULSE might even cost officers and citizens more time and/or lead to worse policing outcomes. This primarily concerns the information surfacing process: when citizens file complaints in person (or come to sign complaints already filed online), the police officers can directly question them about any points of ambiguity or missing information in their complaint statement. Moreover, the interview itself may surface additional information whose relevance the citizen may not realise and the officer is unable to anticipate and ask after independently ("unknown unknowns"). If citizens file entirely online, these opportunities are lost. The officer will have to try to contact the citizen in order to follow up on any ambiguous points, which is liable to require extra time and may create additional obstacles (e.g. missed calls, uncertainty of telephonic identity verification, etc.)

#### 4.2.3.2 Economic Estimate

Unfortunately, Ertzaintza has so far been unable to provide us with the data required for a quantitative economic estimation. The analysis will therefore have to remain qualitative and hypothetical. Table 7 lists the process and time required for filing a complaint via the F2F, existing digital and IMPULSE paths. Note that we assume, based on our conversations with Ertzaintza, that officers of two different ranks are involved.

| Step | Description of Step | Time Required – *F2F Path* – | | | Time Required – *Existing Digital Path* – | | | Time Required – *IMPULSE Path* – | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | *Citizen* | *Junior Officer* | *Senior Officer* | *Citizen* | *Junior Officer* | *Senior Officer* | *Citizen* | *Junior Officer* | *Senior Officer* |
| | | *All times in Minutes* | | | | | | | | |
| **1** | Travel to police station | 15 – 30 | | | 15 – 30 | | | | | |
| **2** | Waiting time at police station | 15 – 20 | | | 15 – 20 | | | | | |
| **3** | Citizen prepares statement / is interviewed by officer (F2F) | 45 – 65 | 45 – 65 | | 20 – 40 | | | 20 – 40 | | |
| **4** | Processing statement with citizens (printing, identity verification, signature etc.) | 15 – 25 | 15 – 25 | | 15 – 25 | 15 – 25 | | | | |
| **5** | Return travel from police station | 15 – 30 | | | 15 – 30 | | | | | |
| **6** | Further processing of the complaint | | 15 | | | 15 | | | 15 | |
| **7** | Consultation with senior officer | | 5 | 5 | | | 5 | | 5 | 5 |
| **8** | Follow-up and clarification of complaints submitted exclusively online | | | | | | | ??? | ??? | |
| ***Total Time Required (in Minutes)*** | | *105–170* | *80–110* | *5* | *80–145* | *30–40* | *5* | *20 – 40 + ???* | *20 + ???* | *5* |

**Table 7: Estimate of time required for filing criminal complaints through different paths**

As can be seen, IMPULSE could offer quite substantial savings, especially for citizens. They could possibly save between 85 and 130 minutes per complaint filed compared to the F2F process, while junior officers could save between 60 and 90 minutes. Possible savings compared to the existing digital path are substantial too, though not quite so great (Table 8). But these estimates still come with considerable uncertainty. In particular, we have not yet been able to get estimates from Ertzaintza about how often they expect to have to follow up with citizens if complaints are submitted wholly online, and how complicated and time-consuming they anticipate this to be. There are also the questions of whether this may impact the quality of the information available to the officers, as well as of a possible increase in submitted complaints, as this now becomes easier. It should be noted that savings may be even greater than implied by Table 8, if Ertzaintza is able to move even more processes online than experimented with in the current pilot.

| | Savings compared to the F2F path | Savings compared to the existing digital path |
|---|---|---|
| **Citizens** | 85 – 130 Minutes? | 60 – 105 Minutes? |

| | | |
|---|---|---|
| **Junior Officers** | 60 – 90 Minutes? | 10 – 20 Minutes? |
| **Senior Officers** | -- | -- |

**Table 8: Possible time savings from IMPULSE**

### 4.2.4 Gijon Case, Spain

#### 4.2.4.1 Description of the Pilot Use Case[46]

The Gijon Pilot use case is special because Gijon already has a well-established, widely-used digital identity and digital government system. This is the so-called "Gijon Citizens' Card"-system, which was begun in 2002. Corner stone of the system is a plastic smart card, which citizens can use as a digital identity to access a wide range of municipal services. Services include paying for public transportation (buses, etc.), borrowing from libraries, scheduling appointments with city offices, reserving sports facilities, short-term rental of bikes and electric cars, paying for parking, and many more.

The card comes with a user account, over which citizens can charge their card with money and monitor and manage their transactions. For the longest period, the citizens had to go to one of the dedicated ATM terminals in Gijon to log into their account (using their card and a PIN, much like a bank card). Since 2019 the plastic citizens' *card* has been complemented by a mobile app (the "Gijon Citizens' App"), through which users can access their account (log-in using their card number and the PIN). The app can be used in much the same way as the smart card and the ATMs; viz. to access some (though not all) of the municipal services accessible through the plastic card, and charge their card/user account and manage transactions. The IMPULSE pilot involves substituting the IMPULSE identity verification system for the app's currently-used system (card number and PIN).

Use of the app has grown relatively slowly. While there are ~340,000 cards in circulation, only ~53,000 unique users have installed the app since 2019. There are at least two likely reasons for this. For one, many services are only accessible through the card, but all services that can be accessed through the app are also accessible through the card. For another, it appears that several of the most intensively-used services can either *only* be accessed through the card, or – if they are also accessible through the app – are likely *easier* to access through the card compared to the app.

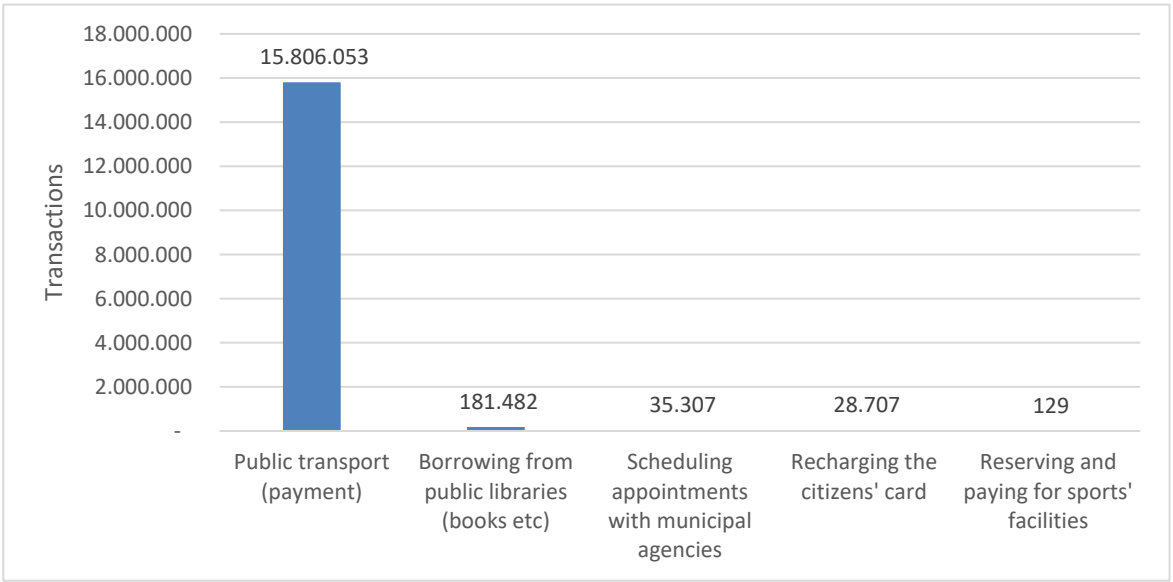


**Figure 13: Most-used Citizen Card and App services: average annual transactions (2019-22)**

Figure 13 shows the five most intensively used citizen card/citizen app services. As can be seen, by far the most intensively-used services are paying for public transport, and library borrowing. Accessing either of these

[46] The following description is based on our interview and follow-up discussions with Reykjavik Pilot staff.

services involves interacting with external physical systems and devices, not just web interfaces – e.g. swiping the card through reader devices to pay or book a loan.

Indeed, public transport payment currently can *only* be done with the card. Enabling payment by app would require installing new and different billing systems in the public buses. It should be noted that there is no obvious benefit from doing so. Indeed, citizens may well find swiping their card to pay much easier than using an app that they would first have to log in to. This is true of many of the other public services offered in Gijon via the citizens' card (e.g. bike and car rental, parking and traffic guidance systems, museum entry, …). Library borrowing can be done both via the app and the card. Again though, it is likely that many citizens find using the card, which be quickly swiped, at least as convenient as the app.

Conversely, numerous other services are likely more easily performed via the app, because they are most conveniently completed through a web interface (mobile or desktop); e.g. scheduling appointments or reserving facilities. Given the usage patterns implied by Figure 13, as well as user inertia, however, it must be assumed that the Gijon digital public services system will for the foreseeable future remain primarily card- and not app-based. This in turn implies strict limits on the potential economic impact of IMPULSE in Gijon.

The main benefits Gijon expects from using the IMPULSE solution for the app are:

- Reduced instances of lost PINs
- Greater security compared to the four-digit PIN
- In the longer term, therefore, potentially the option of offering increasingly sensitive public services via the citizen card/app system
- In the longer term, potentially better interoperability with other municipalities' digital public service provision systems

What economic impacts might this have?

#### 4.2.4.2 Economic impact estimation

The main immediate impact that IMPULSE could have, would be reducing citizens' time lost to resetting lost PINs. On average, in the last two years, there were 2614 PIN reset requests a month, or 31,368 a year. A PIN reset can be requested online, and completed by email or SMS. We assume that the entire process of losing and resetting one's PIN (from mis-entering it three times to accessing the Citizen Card Website, entering one's email or mobile phone number, and receiving the new PIN) takes about 3 minutes. This would imply a total of 31,368 * 3 = 94,104 minutes (1568,4 hours, 65,35 days) of citizen time lost. Applying the average Spanish hourly wage of 17 EUR[47], this would carry a monetary value of EUR ~26.663 a year – though for the citizens, the reduced hassle would likely be more immediately valuable than the (theoretical) monetary saving. Assuming a 90 percent adoption rate for IMPULSE was ultimately reached, this would imply aggregate savings of ~59 days annually for the citizens (~1411 hours, implicitly priced at ~24,000 EUR).

Of course, it is unrealistic to expect citizens to immediately switch to IMPULSE, were this to become available. Adoption would most likely be gradual, with a full conversion to IMPULSE of all citizens likely decades out (unless policy forces citizens to switch faster, e.g. by ending support for PINs.). This in turn means that a reduction in PIN resets is unlikely to produce many direct savings for the municipality. The main direct cost for the municipality of PIN resets is maintaining the necessary IT infrastructure. Since for a long period of time, both IMPULSE and the existing PIN system would likely be used by citizens, this infrastructure would have to be maintained (as well as the new IMPULSE system). In short, this would more likely generate additional net costs, rather than net savings.

It is harder to give an economic value to the other benefits Gijon foresees from moving the App log-in system to IMPULSE. Security breaches can be costly, but it is difficult to make a meaningful quantitative estimate of the gains from moving to a different system (IMPULSE) and thereby avoiding possible future breaches.

[47] Eurostat data. The number is from 2021.
https://ec.europa.eu/eurostat/databrowser/view/LC_LCI_LEV/default/table?lang=en&category=labour.lc.lcan

Likewise, while the idea of offering more sensitive public services through the Card/App system in future is intriguing, at present it is still not clear what services precisely might be offered in this fashion. A benefits assessment is thus not possible. The same goes for greater interoperability with other municipal systems: it is unclear with which services and municipalities interoperability might be sought, making further analysis difficult.

### 4.2.5 Reykjavik Case, Iceland

#### 4.2.5.1 Description of the Pilot Use Case[48]

The Reykjavik Pilot use case involves using the IMPULSE solution as an alternative log-in solution for citizen messaging boards and chat fora. The expectation is that IMPULSE may be useful in particular for handicapped citizens, who struggle with conventional authentication technologies.

We consider this a very worthwhile application of IMPULSE. However, we are not able to identify clear direct or indirect economic effects from it. Therefore, it is not further analysed.

### 4.2.6 InfoCamere Case, Italy

#### 4.2.6.1 Description of the Pilot Use Case[49]

The current iteration of the InfoCamere Pilot use case involves developing IMPULSE as an alternative path for companies to access the so-called "digital drawer" (*cassetto digitale*) with company information. The *cassetto* is a digital version of the national business register, containing the key data about each company operating in Italy. Company representatives access the digital drawer of their company in order to retrieve electronic versions of key documents and data, to identify and authenticate themselves to other companies (business partners, banks etc.).

A widely used digital identity system to authenticate to the *cassetto* already exists. This is the "SPID" system, which uses the user's tax number as identifier, and can be used to authenticate to many other public and private services in Italy. IMPULSE would constitute a further, alternative authentication technology.

While it is always sensible to have multiple distinct technologies for a given task, to add resilience, we have so far not been able to identify a specific advantage of IMPULSE over the SPID system, given that it is already widely used. One potential, albeit longer-term benefit that was highlighted by the InfoCamere staff, was its potential interoperability with other systems in Europe. Were IMPULSE to be truly widely adopted in Europe, this would potentially allow Italian entrepreneurs to reduce the number of digital they use, since they would no longer have to use one identity and system (e.g. SPID) for their domestic activities, and further ones for their business activities elsewhere in Europe. This would certainly be valuable, however, the case is at this point still rather underspecified, so we have refrained from attempting a quantitative evaluation of it in the present version of this Deliverable.

# 5 Conclusion

With regard to our research questions, the following conclusions can now be offered.

*RQ1: What are the specific economic effects of using IMPULSE in the pilot cases?*

*RQ2: How large are the economic effects in the pilot use cases?*

At present, the main economic effect of IMPULSE in the pilot cases is to enable a variety of efficiency gains for both the public administrations and local citizen. Table 9 summarises the maximum possible gains for the use cases where these could be most clearly quantified, Peshtera, Aarhus and Gijon.

Unfortunately, overall savings are relatively small. Even in the best case, and once 90 percent adoption is achieved, Peshtera's civil servants might only save about ~14 working days annually. In Aarhus, best-case

[48] The following description is based on our interview and follow-up discussions with Reykjavik Pilot staff.
[49] The following description is based on our interview and follow-up discussions with InfoCamere Pilot staff.

assumptions lead to about 3 days of working time saved for social services' staff. Over ten years, Peshtera and Aarhus municipalities might save up to BGN 11,600 and 68,000 DKK respectively, or ~6000 EUR and ~9000 EUR. These gross savings moreover need to be set against the expected upfront investment costs for the system, and ongoing operations and maintenance. Once these costs are factored in, it is likely that only very modest savings would remain.

| | Peshtera | | Aarhus | | Gijon | |
|---|---|---|---|---|---|---|
| | For Citizens | For Civil Servants | For Citizens | For Civil Servants | For Citizens | For Civil Servants |
| **Annual Time Savings** | 1564 hours (~65 days) | 107 hours (~14 working days) | 64 hours | • social services staff: 16 hours<br>• parish clerks: 21 hours | ~59 days | -- |
| **Monetary Savings over 10 years** | ~140,000 BGN (71,581 EUR) | ~11,600 BGN (5,931 EUR) | -- | ~68,000 DKK (9,142 EUR) *minus purchase, installation and maintenance costs for lockers* | ~240,000 EUR | -- |

**Table 9: Maximum possible savings in Peshtera, Aarhus and Gijon**

For citizens, the raw time savings (rather than their implicit monetary value) would likely be of greatest significance. Here, savings are somewhat greater. If adoption rates reach 90 percent, citizens in Peshtera would save about 65 days a year, while Gijon's citizens might save about 59 days. Of course, these savings would be distributed across the entire citizen body of the municipality. Savings for the individual citizens would likely amount to between ~1 and ~4 hours a year. This is not a huge sum, but if delivered to the citizen in a "concentrated" form, it may be noticeable: it is the difference between an afternoon devoted largely to government bureaucracy, and an afternoon spent largely with family, hobbies, friends or even work, after quickly completing some forms via one's mobile or desktop.

These rather modest economic effects are in line with the literature, which expects only limited economic gains from the introduction of "basic" digital identity technology (authentication) in the advanced economies. It must be stressed that these modest savings are also a function of the fact that the pilot cases have only explored isolated use cases. However, it is widely recognised that for digital identity to produce significant economic (and social) effects requires enabling large numbers of public and private-sector use cases in parallel. A question worth further exploring is thus what effect IMPULSE might begin to have if more use cases are made available through it, and if the wallet and QES functionalities become available.

*RQ3: Does the use of biometrics for authentication give IMPULSE distinct economic effects, compared to other authentication technologies?*

The answer here is yes. Many of the time savings that IMPULSE creates for citizens depend on the biometric functionality. This reduces onboarding time compared to existing digital solutions (Peshtera pilot) and solves the problem of forgotten PINs (Gijon). Biometrics is crucial to the value proposition of the lockers deployed in the Aarhus pilot: if the lockers relied on traditional physical keys or numerical codes, instead of the IMPULSE technology, they would likely just displace the problem of small, high-value objects getting lost, that is at the core of the Aarhus use case. (Now the locker keys would get lost instead of the NemID cards.)

Not explored so far but an important question, is to what extent IMPULSE could increase the use of services in the private sector, by making onboarding faster and eliminating the problem of lost passwords. Drawing on data collected in WP 4.1 of the IMPULSE project, this may be examined in the next version of this Deliverable.

*RQ 4: What economic effects could adding a Digital Wallet and QES functionality to IMPULSE have? What are the economic effects of their current lack in the IMPULSE solution?*

*RQ 5: Does being an SSI solution give IMPULSE particular economic effects, that other eID architectures will necessarily lack?*

These questions could not so far be explored empirically in the pilot use cases. For the reasons discussed in chapter 3.2.4, it is likely that the addition of the digital wallet and QES functionalities would increase the economic impact of IMPULSE. A task for the next version of this Deliverable is to explore how the possible effects of adding them to IMPULSE could be estimated.

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# Annex A List of Interviews

| Interview | Date | Interviewees from Case Owner |
|---|---|---|
| **Aarhus** | 20 April 2022 | Janni Sovang, Lasse Nielsen |
| **Reykjavik** | 21 April 2022 | Kristrun Gunnarsdóttir |
| **Municipality of Peshtera** | 22 April 2022 | Georgi Simeonov |
| **InfoCamere** | 29 April 2022 | Marco Vianello, Nicolo Fassa, Domenico Racantelli |
| **Ertzaintza** | 13 May 2022 | Andoni Osoro |
| **Gijon** | 27 May 2022 | Pedro López Sánchez |

**Table 10: List of interviews conducted**

# Annex B Questionnaire for Interviews with Case Owners

1. **What is the precise content of the public service of the finalised case?**
   - Who is it for? (Who are the service recipients?)
   - What benefits does it provide them?
   - Among the service recipients (users), are there particular groups who use the service most (e.g. particular age groups, men/women, people in specific family/life circumstances, more educated/less educated, citizens/non-citizens, disabled or people in ill-health vs healthy/fully-abled, people living in urban vs rural areas …)? Is there a "typical" user?
   - Are there particular groups who would be eligible for the service, but seem to use it especially *little*?
   - If so, do you have any thoughts about why particular groups may use it esp. much / little?
   - Are there particular user groups should be better reached with the future solution and why?
   - More broadly, what are the interests and "life situation" of the users/service recipients? What is important to understand about them in order to be able to understand the IMPULSE case?
2. **How is the service delivered at present (pre-IMPULSE)?**
   - What are the individual steps through which it is currently delivered?
   - What mode(s) of electronic or analog authentication is (are) used? How do these work? (e.g. username/password-based, smartcard, 2-factor …)
   - What administrative and IT systems are involved in the current mode of service delivery?
   - Which individuals (public servants) and departments/units in the public administration are involved in providing the service? What exactly do these individuals / units do (what are their tasks?)
   - What are the "interests" and concerns of these individuals and units/departments as regards the provision of the public services? What are the larger framework conditions under which they operate?
3. **What are the main advantages and disadvantages of the current mode of service delivery?**
   - For the users / citizens?
   - For the public servants?
   - For any others? (3rd parties somehow involved in or affected by the service / service delivery)
   - If you as case owners or public servants could change 1, 2, or 3 aspects of how the service is currently delivered, what would you change? Why?
   - What are the 1, 2 or 3 things you would definitely want to preserve? Why?

4. **How is the service to be delivered in the IMPULSE pilot? Please walk us through the individual steps that the users (service recipients) and the civil servants who are involved must take, and help us identify what is different compared to pre-IMPULSE.**

5. **What benefits is the IMPULSE mode of delivering the service expected to offer:**
   - the service recipients (users)?
   - the public servants involved in service delivery?
   - the public administration as a whole?
   - any other stakeholders (3rd parties)?

6. **Could the IMPULSE mode of delivering the service have any disadvantages for:**
   - the service recipients (citizens)?
   - the public servants involved in service delivery?
   - the public administration as a whole?
   - any other stakeholders (3rd parties)?

7. **Do you think there might be acceptance problems, and what would these be**
   - among the service recipients?
   - among the public servants involved in service delivery?
   - Among the public administration as a whole?

Thinking beyond the current use case, are there other applications of IMPULSE (e.g. other use cases) in your organisation or related organisations that you could imagine?