

Public Investment in Belgium

Current State and Economic Impact

January 2017

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Abstract - Belgian government investment, and specifically the part spent on infrastructure, is relatively low both in historical terms and compared to neighbouring countries. A simulation with the European Commission's Quest III model suggests that increasing government investment permanently by 0.5% of GDP leads to a growth in GDP, private consumption and private investment. The impact of alternative financing mechanisms is compared. Finally, a budget neutral shift of investment in favour of infrastructure is found to yield significant benefits in terms of GDP and its main components already in the medium run.

Abstract - L'investissement des autorités publiques belges, et en particulier la part consacrée à l'infrastructure, est relativement faible à la fois historiquement et en comparaison avec les pays voisins. Une simulation à l'aide du modèle Quest III de la Commission européenne suggère qu'une augmentation permanente de l'investissement du gouvernement de 0,5% du PIB augmente le PIB, la consommation privée et l'investissement privé. L'impact de mécanismes alternatifs de financement est comparé. Finalement, une réallocation, budgétairement neutre, de l'investissement en faveur de l'infrastructure conduirait, déjà à moyen terme, à des gains substantiels de PIB et de ses principales composantes.

Abstract - De Belgische overheidsinvesteringen, en in het bijzonder het deel ervan dat aan infrastructuur wordt besteed, relatief laag ligt in historische context en in vergelijking met de buurlanden. Een simulatie met het QUEST III- model van de Europese Commissie suggereert dat een permanente stijging van de overheidsinvesteringen met 0,5% van het bbp leidt tot een groei in bbp, particuliere consumptie en particuliere investeringen. De impact van alternatieve financieringsmechanismen wordt vergeleken. Ten slotte blijkt dat een budget-neutrale verschuiving van overheidsinvesteringen ten gunste van infrastructuurwerken belangrijke voordelen oplevert in termen van het bbp en zijn belangrijkste componenten, en dit reeds op middellange termijn.

Jel Classification - E27, E62, H54

Keywords - Public investment, Infrastructure, Public finance, General equilibrium, Simulation

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Executive summary

Can additional government investments in Belgium result in higher economic growth? This question has recently come under the spotlight following recommendations in this direction by international organisations like the European Commission and the IMF. By contrast, in Belgium, government investment has decreased from more than 5% of GDP on average during the 1970s to 2.4% of GDP in 2015. Since the end of the 1980s, gross investment has not always been sufficient to compensate for the depreciation of the installed capital. Since 1995, the government net capital stock has decreased by almost 15 percentage points of GDP, reaching 36.5% of GDP in 2015, a figure that is significantly lower than in the neighbouring countries. Not only has government investment in Belgium decreased, but its composition has also changed. The share of infrastructure investment, considered to be the type of government investment with the highest growth potential, decreased from 35% in 2006 to 26% in 2014. Consequently, Belgian government infrastructure investment reached 0.6% of GDP in 2014 compared to almost 1% in the Euro Area.

To shed more light on the question above, the effects of an increase in government investment on the Belgian economy were simulated using the QUEST III model of the European Commission, adjusted to the current situation of the country. The main advantage of this model is the availability of a country-specific version for Belgium, with economic ties to the rest of the Euro Area and the rest of the world.

The FPB has a long tradition of calculating the impact of economic shocks on the Belgian economy. In previous exercises, the demand-driven model HERMES has been used to stimulate a shock of public investment (see Bassilière et al., 2013). In comparison to this previous simulation, this exercise allows to also include the positive impact of government investment on the production function of the private sector.

The basic simulation involves a permanent budget neutral increase in government investment of 0.5% of GDP which corresponds to an additional investment of about 2 billion euros per year. This amount is in line with Belgian proposals to work out the public infrastructure pillar of the Investment Plan for Europe. It is found that real GDP rises by 0.24% after one year and by 2.77% after twenty years relative to the baseline. The largest share of this increase reflects higher labour productivity, though employment itself also slightly rises. Both private consumption and private investment increase by 1.5% relative to the baseline after twenty years. Initially, the GDP deflator rises slightly as a result of increased demand, but in the long term the productivity growth lowers domestic producer prices by 1.3%, leading to a curtailment of inflation. Overall, a stylized head tax (lump-sum tax) of 0.13% of GDP is necessary to keep government finances stable at the current level. This excludes the possibility of a self-financed measure (or 'fiscal free lunch'), because this would lead to a head tax equal to or smaller than zero. At the same time, the resulting economic growth ensures that only a quarter of the invested amount has to be covered by new government revenues.

Additional simulations were performed to check how these results would change if the measure was financed either by a more realistic tax (on labour, on capital or on consumption), by a reduction in government consumption or by a public debt increase. In the long run, financing through debt or through

a higher consumption tax turns out to have almost the same positive effect on GDP as under the basic stylized head tax, i.e. 2.69%. The results of the consumption tax scenario, however, are likely to be over-estimated since the model does not fully include the Belgian wage formation mechanism. If the measure is financed by cutting other government expenses, GDP still rises by 2.43% after twenty years relative to the baseline. A tax on labour or capital income detracts the most from the positive effects, at least concerning GDP, limiting its growth to 1.69% and 1.89% respectively. The former thereby mainly hampers employment and private consumption, while the latter causes private investments to fall. Private consumption is maximal under a cut in other government expenditures, because this scenario does not lead to additional taxes or government debt (i.e. postponed taxes). If only debt financing is considered, public debt increases and the debt-to-GDP ratio reaches 112% after twenty years, hereby rendering the evolution of public finances unsustainable. Evidently, this comparison has to be interpreted with the necessary caution: on the one hand the different financing mechanisms have been modelled in a stylized way, while on the other hand GDP and private consumption, certainly within an economic model, can only partly capture household welfare.

Starting from the observation that infrastructure investments have a larger effect in terms of GDP than other government investments (hospitals and schools, public goods and redistribution), a shift in expenditures from the latter to the former has been simulated. After only three years, this scenario results in a 1.2% increase in GDP growth relative to the baseline. Moreover, initially budget neutral, this shift leads to higher government revenues which can be used to lower the tax burden and/or the public debt ratio.

Finally, sensitivity analyses were carried out for the most important parameters underlying this study. Not unexpectedly, the effect of the parameter representing the impact of a growth of public capital on output growth, the so-called output elasticity of public capital, is crucial for these conclusions. A more conservative estimate of this elasticity (50% lower) would, in the basic scenario, yield a GDP growth of only 1.48% instead of 2.77% after twenty years, while increasing the parameter's value by 50% would yield a growth of 4.2%. So, even though the value used in the basic simulation was chosen with care and is located in the middle of the interval of empirical estimates, these results should be interpreted with caution.

In conclusion, the simulation suggests that raising government investment in Belgium supports GDP, private consumption, and private investment growth without inflationary effects. This increase is only partially self-financing, however, so that a budgetary compensation is necessary to prevent government debt from growing. Policy priorities should determine which financing mechanism has to be adopted. Finally, a mere shift between government investment types in favour of infrastructure, without additional budgetary means, already has a quite substantial positive impact on GDP and its main components.

Synthèse

La croissance économique peut-elle être stimulée par des investissements publics supplémentaires ? Cette question revient sur le devant de la scène suite aux recommandations en la matière des organisations internationales comme la Commission européenne ou le FMI. En revanche, en Belgique, le taux d'investissement des autorités publiques a diminué, passant de plus de 5% du PIB en moyenne dans les années septante à 2,4% du PIB en 2015. Depuis la fin des années quatre-vingt, l'investissement brut n'a pas toujours été suffisant pour compenser la dépréciation du capital installé. Le stock net de capital public a donc diminué de près de 15 points de pourcentage du PIB depuis 1995, s'élevant à 36,5% du PIB en 2015, un chiffre largement inférieur à celui observé dans les pays voisins. En Belgique, l'investissement public n'a pas seulement diminué, sa composition s'est également modifiée. La part des investissements en infrastructure, considérés comme les investissements dotés du potentiel de croissance le plus élevé, est passée de 35% en 2006 à 26% en 2014. En conséquence, l'investissement belge en infrastructure s'élevait à 0,6% du PIB en 2014 contre près de 1% dans la zone euro.

Pour tenter de répondre à cette question, les effets sur l'économie belge d'une augmentation des investissements des autorités publiques ont été simulés à l'aide du modèle QUEST III de la Commission européenne, mis à jour pour tenir compte de la situation actuelle de notre pays. Le principal avantage de ce modèle est la disponibilité d'une version spécifique à la Belgique incluant des liens économiques avec le reste de la zone euro et le reste du monde.

Le BFP a une longue tradition de calcul de l'impact de chocs sur l'économie belge. Dans un exercice précédent, le modèle déterminé par la demande HERMES a été utilisé pour simuler l'impact d'un choc d'investissement public (Bassilière et al., 2013). En comparaison avec cette simulation, cet exercice permet de prendre aussi en considération l'impact positif de l'investissement public sur la fonction de production du secteur privé.

La simulation de base correspond à une augmentation permanente, budgétairement neutre, des investissements des autorités publiques de 0,5% du PIB, ce qui correspond à un investissement supplémentaire de 2 milliards d'euros par an. Ce montant est conforme aux propositions belges pour la réalisation du pilier des infrastructures publiques du Plan d'Investissement pour l'Europe. Dans le cadre de cette première simulation, le PIB en volume augmente de 0,24% après un an et de 2,77% après 20 ans par rapport au scénario de référence (en l'absence de choc). Cette croissance du PIB s'explique principalement par une croissance de la productivité du travail, bien que l'emploi augmente aussi légèrement. La consommation privée et l'investissement privé augmentent, après 20 ans, de 1,5% par rapport au scénario de référence. Le déflateur du PIB s'accroît d'abord légèrement suite à l'augmentation de la demande, puis à long terme, la croissance de la productivité fait diminuer les prix de la production domestique de 1,3%, ce qui entraîne une baisse de l'inflation. Dans l'ensemble, une taxe forfaitaire par personne stylisée (lump-sum tax) de 0,13% du PIB est nécessaire pour stabiliser les finances publiques au niveau actuel. Cela exclut la possibilité d'une mesure autofinancée (appelée "free lunch" fiscal) qui se traduirait par une taxe forfaitaire individuelle égale ou inférieure à 0. En même temps, vu la croissance économique générée, seul un quart du montant investi doit être couvert par de nouvelles recettes publiques.

Des simulations supplémentaires ont été effectuées pour vérifier dans quelle mesure les résultats changent lorsque la mesure est financée soit par un impôt plus réaliste (sur le travail, le capital ou la consommation), soit par une réduction de la consommation publique, soit par une augmentation de la dette publique. À long terme, le financement par dette ou par augmentation de l'impôt sur la consommation s'avère avoir presque le même impact positif sur le PIB que la taxe stylisée de la simulation de base, soit 2,69%. Les résultats du scénario de l'impôt sur la consommation sont cependant susceptibles d'être surestimés vu que le modèle n'inclut pas entièrement le mécanisme belge de formation des salaires. Lorsque la mesure est financée par une réduction des autres dépenses publiques, le PIB augmente toujours, après 20 ans, de 2,43% par rapport au scénario de référence. Un impôt sur les revenus du travail ou du capital réduit le plus les effets positifs, au moins en ce qui concerne le PIB, limitant ainsi sa croissance à respectivement 1,69% et 1,89%. Le premier nuit principalement à l'emploi et à la consommation privée, tandis que le second conduit à une chute des investissements privés. La consommation privée est maximale lors d'une réduction des autres dépenses publiques parce que ce scénario ne mène pas à un accroissement des impôts ou de la dette publique (c'est-à-dire à des impôts différés). Si seul est pris en compte le financement par endettement, la dette publique augmente et le ratio de dette sur PIB atteint 112% après 20 ans, rendant l'évolution des finances publiques insoutenable. Cette comparaison doit, bien sûr, être interprétée avec la prudence nécessaire : d'une part, les différents mécanismes de financement ont été modélisés de façon stylisée et d'autre part, le PIB et la consommation privée, certainement au sein d'un modèle économique, ne rendent que partiellement compte du bien-être des ménages.

Partant de l'observation que les investissements en infrastructure ont un effet plus important sur le PIB que les autres investissements publics (hôpitaux et écoles, biens publics et redistribution), un changement dans les dépenses en faveur des infrastructures a été simulé. Déjà après 3 ans, ce scénario aboutit à une croissance du PIB de 1,2% par rapport au scénario de référence. De plus, budgétairement neutre au départ, ce changement génère des recettes additionnelles qui peuvent être utilisées pour réduire la charge fiscale et/ou le ratio de la dette publique.

Enfin, des analyses de sensibilité ont été menées pour les paramètres les plus importants de l'étude. Comme attendu, l'effet du paramètre représentant l'impact de la croissance du capital public sur la croissance de la production, communément appelé élasticité de la production par rapport au capital public, est crucial pour ces conclusions. Une estimation plus modérée (inférieure de 50%) donnerait, dans la simulation de base, une croissance du PIB après 20 ans d'à peine 1,48% contre 2,77%, tandis qu'une augmentation de la valeur du paramètre de 50% pousse la croissance à 4,2%. En conséquence, bien que la valeur utilisée dans la simulation de base ait été choisie avec prudence et se situe au milieu de l'intervalle des estimations empiriques, la prudence est de mise quant à l'interprétation de ces résultats.

En conclusion, la simulation suggère qu'augmenter l'investissement des autorités publiques en Belgique soutient la croissance du PIB, de la consommation privée et de l'investissement privé sans effet inflationniste. Cette augmentation ne s'autofinance cependant que partiellement et une compensation budgétaire est donc nécessaire pour empêcher un accroissement de la dette publique. Les priorités d'ordre politique devraient déterminer quel mécanisme de financement doit être adopté. Enfin, une simple réallocation des investissements publics en faveur des infrastructures, sans moyens budgétaires additionnels, a déjà un effet positif assez substantiel sur le PIB et ses principales composantes.

Synthese

Kunnen bijkomende overheidsinvesteringen in België de economische groei aanzwengelen? Die vraag kwam recent in de schijnwerpers te staan door aanbevelingen in die zin van internationale organisaties zoals de Europese Commissie en het IMF. Daartegenover staat de vaststelling dat de overheidsinvesteringen in België zijn gedaald van jaarlijks gemiddeld 5% van het bbp in de jaren zeventig tot 2,4% van het bbp in 2015. Sinds het einde van de jaren tachtig zijn de bruto-investeringen niet altijd toereikend geweest om de afschrijving van het reeds bestaande publieke kapitaal op te vangen. Zo is het netto kapitaal in overheidshanden sinds 1995 gedaald met bijna 15 procentpunt tot 36,5% van het bbp in 2015, een niveau dat aanzienlijk lager ligt dan dat van de ons omringende landen. De overheidsinvesteringen zijn niet alleen gedaald, maar de samenstelling ervan is ook veranderd. Het aandeel van de infrastructuurinvesteringen, die worden beschouwd als het type overheidsinvesteringen met de grootste potentiële weerslag op de economische groei, daalde van 35% in 2006 tot 26% in 2014. Als gevolg daarvan bedroegen de Belgische overheidsinvesteringen in infrastructuur 0,6% van het bbp in 2014, tegenover bijna 1% in de eurozone.

Om meer duidelijkheid over dit vraagstuk te krijgen, werden de gevolgen van een stijging van de overheidsinvesteringen op de Belgische economie in kaart gebracht met behulp van het QUEST III-model van de Europese Commissie, dat werd geüpdatet om rekening te houden met de huidige toestand van het land. Het belangrijkste voordeel van dat model is dat er een versie van bestaat die specifiek is toegespitst op België, met inbegrip van de economische banden met de rest van de eurozone en de rest van de wereld.

Het FPB kent een lange traditie in het berekenen van de impact van economische schokken op de Belgische economie. In vroegere toepassingen werd het door de vraag gedreven model HERMES gebruikt om een publieke investeringsschok te simuleren (zie Bassilière et al., 2013). In vergelijking met deze eerdere simulatie, laat de huidige oefening toe om ook de positieve impact van overheidsinvesteringen op de productiefunctie van de private sector in rekening te brengen.

De basissimulatie van de studie bestaat uit een permanente, budget-neutrale verhoging van de overheidsinvesteringen met 0,5% van het bbp, wat neerkomt op een bijkomende investering van ongeveer 2 miljard euro per jaar. Dat bedrag is gebaseerd op de Belgische voorstellen om invulling te geven aan de pijler publieke infrastructuur van het Europese Investeringsplan. Volgens de resultaten van de simulatie stijgt het bbp met 0,24% na één jaar en met 2,77% na twintig jaar, in vergelijking met de startwaarde. Die stijging is grotendeels toe te schrijven aan een hogere arbeidsproductiviteit, en in mindere mate aan een hogere tewerkstelling. Zowel de particuliere consumptie als de particuliere investeringen stijgen met 1,5% van het bbp ten opzichte van de startwaarde na twintig jaar. De bbp-deflator neemt aanvankelijk licht toe door de toenemende vraag, maar op langere termijn zorgt de productiviteitsgroei voor een daling van het prijspeil van de binnenlandse productie met 1,3%, waardoor de maatregel een remmend effect heeft op de inflatie. Om de overheidsfinanciën stabiel te houden op het huidige niveau, is een gestileerde hoofdelijke (lumpsum) belasting nodig van 0,13% van het bbp. Daaruit blijkt dat de maatregel zichzelf niet zou financieren (een zgn. fiscale 'free lunch'), want dan zou de hoofdelijke belasting kleiner of gelijk aan nul zijn. Toch zorgt de economische groei die uit die maatregel voortvloeit

ervoor dat voor slechts een kwart van het geïnvesteerde bedrag effectief overheidsmiddelen moeten worden gezocht.

Bijkomende simulaties werden uitgevoerd om na te gaan hoe die resultaten veranderen als de maatregel gefinancierd wordt door een meer realistische vorm van belasting (nl. op inkomen uit arbeid of kapitaal of op consumptie), door een besparing op de overheidsconsumptie of door de overheidsschuld te laten oplopen. Op lange termijn blijken schuldfinanciering en financiering via een hogere belasting op consumptie bijna dezelfde positieve effecten op het bbp te hebben als onder de gestileerde hoofdelijke belasting in de basissimulatie, nl. 2,69%. De resultaten met betrekking tot de consumptiebelasting vormen daarbij waarschijnlijk een overschatting omdat het specifieke loonvormingsmechanisme in België niet volledig in het model vervat zit. In het scenario waarbij de financiering gebeurt via een besparing op andere overheidsuitgaven, stijgt het bbp, met 2,43% na twintig jaar ten opzichte van de startwaarde. Belastingen op het inkomen uit arbeid en kapitaal beperken de positieve effecten – althans op het bbp – het meest. In dat scenario stijgt het bbp respectievelijk slechts met 1,69% en 1,89%. Het eerste belastingtype zet daarbij een rem op de extra tewerkstelling en particuliere consumptie, terwijl het tweede type de particuliere investeringen doet teruglopen. De particuliere consumptie is dan weer maximaal in het scenario waarbij op de overheidsconsumptie wordt bespaard, omdat dat geen bijkomende belastingen of overheidsschuld (beschouwd als uitgestelde belastingen) met zich meebrengt. Wanneer de financiering enkel via schuld gebeurt, loopt de overheidsschuld op en bedraagt de schuldgraad 112% na twintig jaar, waardoor de overheidsfinanciën dus onhoudbaar worden. Deze vergelijking moet uiteraard met de nodige voorzichtigheid worden geïnterpreteerd: enerzijds zijn de verschillende types van financiering op een gestileerde manier vormgegeven, terwijl anderzijds het bbp en de particuliere consumptie – zeker binnen een economisch model – maar tot op zekere hoogte de welvaart van de bevolking weergeven.

Uitgaande van de vaststelling dat infrastructuurinvesteringen een groter effect op het bbp hebben dan andere overheidsinvesteringen, werd een shift binnen de investeringsuitgaven gesimuleerd waardoor relatief meer in infrastructuur wordt geïnvesteerd en minder in andere domeinen (ziekenhuizen en scholen, publieke goederen en herverdeling). Dat scenario leidt al na drie jaar tot een bbp-groei van 1,2% ten opzichte van de startwaarde. Waar de verschuiving aanvankelijk budgetneutraal is, leidt ze bovendien tot hogere inkomsten voor de overheid, waardoor de belastingdruk en/of de schuldgraad kan worden verlaagd.

Ten slotte werden gevoeligheidsanalyses uitgevoerd voor de parameters die heel belangrijk zijn voor deze oefening. Niet onverwacht is vooral het effect van de parameter die de impact weergeeft van hoger publiek kapitaal op de outputgroei, de zgn. outputelasticiteit van publiek kapitaal, cruciaal voor de bevindingen die worden gepresenteerd. Een conservatievere schatting ervan (50% lager) zou het bbp in het basisscenario slechts met 1,48% in plaats van 2,77% doen toenemen na twintig jaar, terwijl een verhoging van de waarde van de parameter met 50% leidt tot een groei van 4,2%. Hoewel de waarde die werd gebruikt voor de basissimulatie met zorg werd gekozen en zich in het midden van het bereik van de empirische schattingen bevindt, moeten die resultaten met voorzichtigheid worden geïnterpreteerd.

Bij wijze van conclusie suggereert de simulatie dat een stijging van de overheidsinvesteringen in België leidt tot een toename van het bbp, de particuliere consumptie en de particuliere investeringen, zonder

extra prijsstijgingen te veroorzaken. De maatregel financiert zichzelf echter slechts gedeeltelijk, zodat deels ook bijkomende overheidsmiddelen moeten worden gezocht om een stijging van de overheidsschuld te vermijden. Via welke weg de financiering dient te gebeuren, hangt af van de beleidsprioriteiten. Ten slotte zou een loutere verschuiving tussen verschillende types overheidsinvesteringen in de richting van meer infrastructuur, zonder bijkomende budgettaire middelen, reeds een aanzienlijke positieve impact hebben op het bbp en zijn belangrijkste componenten.

Introduction

In response to the long-lasting effects of the Great Recession on the potential growth of the Member States, the European Union considers the recovery in investment as a priority. The European Commission has operationalised this priority into the Investment Plan for Europe (IPE) aiming at fostering government and business investment in Member States. At the same time, pressures on the Member States have increased in the context of the European Semester with more Country Specific Recommendations (CSRs) related to investment. Belgium does not form an exception to this rule and the third recommendation addressed to Belgium by the Council of the European Union in July 2016 included: ‘(...). Address shortfalls in investment in transport infrastructure and energy generation capacity.’ The increase in government investment is however conditioned by the sustainability of public finances which imposes a sound path to the public deficit and debt-to-GDP ratios.

The Federal Planning Bureau has a long experience of simulating the impact of policy measure on the Belgian economy based on a demand-driven macro-econometric model, HERMES. In Bassilière et al. (2013), the impact of a permanent increase in public investment over an eight-year period was presented. However, in this simulation, the potential positive supply-side effect of public investment was not investigated¹. To take on board the impact of public investment on the production function of the private sector, another family of models should be mobilised.

This working paper examines the economic effects on the Belgian economy of a structural realistic increase in government investment, using the European Commission’s QUEST III model, slightly modified to better correspond to the current situation. It is found that beyond the short term positive impact on GDP through the demand channel, the increase in government investment also boosts the long-term growth through the positive impact on productivity and, to a lesser extent, on labour utilisation. The increase in government investment also crowds in private sector investment. The boost of potential output prevents overheating and inflation decreases after a limited, temporary swell. The fiscal impact in terms of public deficit rate is less than one-on-one, reflecting the positive effects of government investment increase on demand in the short run and on productivity in the long run. However, a tax is required to keep the debt-to-GDP ratio from rising. The increase in government investment is thus not fully self-financed (i.e. there is no fiscal free lunch).

The paper is organised as follows. After a first section devoted to the clarification of the different concepts usually used in the literature, the second section allows to underline the strong decrease in the Belgian government investment rate since the beginning of the seventies and the changes in the composition of this investment at the expense of infrastructure investment. In the third section, a brief survey of the relevant transmission channels identified by the literature is done. In the fourth section, a description of the QUEST model’s most important relationships is provided and calibration issues are discussed. The main results of a structural increase in the government investment by 0.5% of GDP are commented in the fifth section. Alternative simulations are also presented which explores the results of different financing modes and of a shift between different types of government investment. The sixth

¹ Annex B in this paper gives a small overview of the HERMES model. It makes the point that the model is a medium-term model, giving prevalence to demand aspects.

section presents the sensitivity analysis of the results in function of different values for important parameters of the model, such as the output elasticity of public capital, the elasticity of substitution of imports and domestic production or the proportion of liquidity constrained households. Finally, the last section concludes and discusses the analysis' limitations as well as directions for further research.

The authors thank the teams Public finances and Sectoral and environmental accounts and analyses for their valuable help.

1. Definitions

In most empirical papers on public investment, different terms are used as synonyms although they cover very different realities. These terms are government investment, public investment or infrastructure investment. To avoid such a confusion, it is useful to choose a statistically well-defined concept. General government gross fixed capital formation is the central concept of this working paper. This concept corresponds to investment of all public administrations included in the institutional sector 'General government', S13, as defined by Eurostat under the conceptual framework of the European System of National and Regional Accounts (ESA 2010) and of the Manual on Government Deficit and Debt – Implementation of ESA2010.²

According to ESA2010 (§ 3.124), 'gross fixed capital formation consists of resident producers' acquisitions, less disposals, of fixed assets during a given period plus certain additions to the value of non-produced assets realised by the productive activity of producer or institutional units. Fixed assets are produced assets used in production for more than one year'. The gross term means that investment is measured before the deduction of consumption of fixed capital (depreciation). The gross fixed capital formation does not include usual maintenance costs of installed capital but only major improvements to a fixed asset. Maintenance expenditures are recorded as current expenditures (government consumption) and are thus not included in government investment (European Commission, 2016b).

The General government sector has four subsectors: Central government, State government, Local government and Social security funds.

Statistics on General government investment are directly available in national accounts for each Member State. They are ventilated according to the UNSD classification of functions of government (COFOG), replicated in ESA2010. This classification distinguishes 10 main functions: General public services, Defence, Public order and safety, Economic affairs, Environment protection, Housing and community amenities, Health, Recreation, culture and religion, Education and Social protection. The importance of government investment in each of these functions depends on the subsector of government considered.

Contrary to what is often thought, all entities controlled by government are not statistically classified in S13 generally because these entities are considered as 'market producer' by the ESA rules. The national railway company (NMBS/SNCB) or gas and water grid companies such as FLUXYS or VIVAQUA are

² The general government sector consists of institutional units which are non-market producers whose output is intended for individual and collective consumption, and are financed by compulsory payments made by units belonging to other sectors, and institutional units principally engaged in the redistribution of national income and wealth (ESA 2010 § 2.111). The institutional units included to general government sector (S.13) according to ESA 2010 (§ 2.112) are the following: a) general government units which exist through a legal process to have judicial authority over other units in the economic territory, and administer and finance a group of activities, principally providing non-market goods and services, intended for the benefit of the community; b) a corporation or quasi-corporation which is a government unit, if its output is mainly non-market and a government unit controls it; c) non-profit institutions recognised as independent legal entities which are non-market producers and which are controlled by general government; and d) autonomous pension funds, where there is a legal obligation to contribute, and where general government manages the funds with respect to the settlement and approval of contributions and benefits.

examples of companies owned by government but classified outside the S13 sector. The National Accounts Institute (NAI) publishes the list of these entities on its website.³ The delimitation of the general government sector perimeter is of main importance in the context of the fiscal surveillance procedure of the European Union. The general government perimeter has been recently enlarged notably by including highly indebted social housing companies and by incorporating entities or operations bearing future liabilities (e.g. investment aid granted to hospitals and PPP's projects, see Box 1). This broadening led to an increase in both the deficit and public debt, impacting at the same time the sustainability of public finances. Public sector investment in broad terms could then be defined as investment of general government augmented by investment of all these entities controlled by government. There is no directly available statistic on this concept.

Box 1 Public Private Partnerships (PPPs): an alternative way to stimulate government investment in infrastructure?

The launch of the Investment Plan for Europe (IPE) has renewed the interest for the public private partnership in large infrastructure projects. The IPE objective is indeed not only fostering government investment but also mobilizing private capital and expertise. The recording of PPPs on or off the government sector perimeter (S13) has attracted increased attention in this context, particularly in countries where public debt is already at a high level. The lack of clarity on the rules followed by Eurostat has hampered the development of such projects. A Belgian example of this problem is given by the debate surrounding the tram infrastructure PPP for the city of Liège. Eventually, in September 2016, Eurostat and the European PPP Expertise Centre published an exhaustive guide to the statistical treatment of PPPs that allows to anticipate more easily the accounting classification (in or out S13) of a given PPP project. However, this needed clarification of rules is not a sufficient condition to launch a wave of infrastructure PPPs in countries such as Belgium which are continuously under the threat of the excessive deficit procedure of which criteria have not been changed.

Contrary to a common misunderstanding, all government investments are not infrastructure investments and all infrastructure investments are not only realised by the government sector. Part of government investment, for instance, consists of buildings for its administration which are not considered as an infrastructure investment, while the electrical infrastructure investment in Belgium is mainly developed by private sector enterprises.

As there is no generally-accepted definition of infrastructure, we start with the definition of infrastructure as physical or intangible assets (see Box 2) constitutive of utilities and facilities that provide essential services and help drive economic growth. Two categories of infrastructure are identified:

- Utilities: covering infrastructure in energy, communications, water and waste management;
- Transport infrastructure covering assets such as airports, roads, seaports or rails.

Based on this definition and following Bom and Ligthart (2014), it is then possible to identify the share of government investment devoted to infrastructure using the COFOG classification.⁴ However, to put these figures into perspective, it is useful to know the infrastructure investment of the whole economy, investment implemented both by the public and the private sector. Indeed, there are large differences in public-private sharing of infrastructure investment between countries.

³ <http://inr-icn.fgov.be/fr/content/comptes-nationaux-et-regionaux>

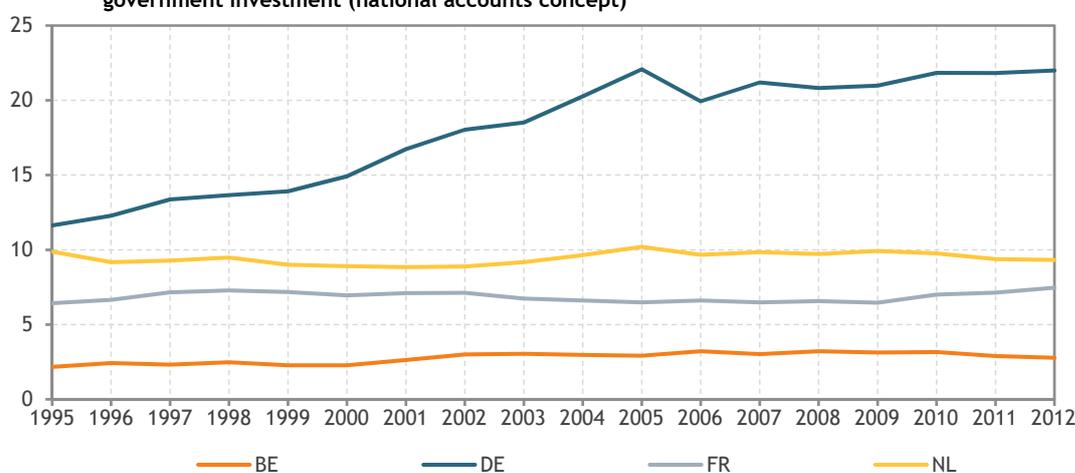
⁴ Adaptation of Bom and Ligthart (2014) definition of infrastructure to the new ESA leads to consider as infrastructure the following COFOG codes: 04.3, 04.4, 04.5, 04.6, 04.8, 05.1, 05.2 and 06.03 (see Annex A, Table A.1)

Box 2 Tangible and intangible assets

Among the categories of assets included in national accounts as investment, R&D, Computer software and databases and Other intellectual property products are the only intangible assets taken into consideration. However, intangible assets could also incorporate other assets such as advertising, design, market research, organisational capital and training as underlined by Corrado, Hulten and Sichel (2005, 2009).

The SPINTAN (Smart Public Intangible) project funded by the seventh framework program of the European Union aims at building a public intangible database for 22 EU countries and the United-States over 1995-2012. When taken into account, these intangible assets not yet included in national accounts increase government investment with respect to the current estimate but this increase varies from a country to another. The graph B1 illustrates the increase in general government investment in Belgium and in the three main neighbouring countries over 1995-2012 when additional intangible assets identified by the SPINTAN project are taken into consideration.

Graph B1 Increase of General government investment due to additional intangible assets in % of General government Investment (national accounts concept)



Source: SPINTAN database.

The increase in government investment is the smallest in Belgium (only 2.8% in 2012) and the largest in Germany with an increase of 22% in 2012. The organisational capital accounted for the largest share of additional intangible assets in the Netherlands (69% in 2012), in Belgium (57%) and in France (52%) while in Germany, it was the training (68% in 2012).

Measuring infrastructure investment for the whole economy requires a different approach than the one adopted for measuring government infrastructure investment. Indeed, the classification of expenditures by function (COFOG) is only available for the government. In national accounts, gross fixed capital formation of the whole economy is ventilated by industries and by assets. The main categories of assets are Dwellings, Non-residential buildings & other structures, Transport equipment, Computer & hardware, Telecoms, Other machinery and equipment & weapon systems, Cultivated biological resources, Research and development, Computer software and databases and Other intellectual property products.

Based on these categories, we can define infrastructure investment in a prudent way as investment in Other structures, corresponding principally to transport infrastructure and Telecoms.⁵ Infrastructure in

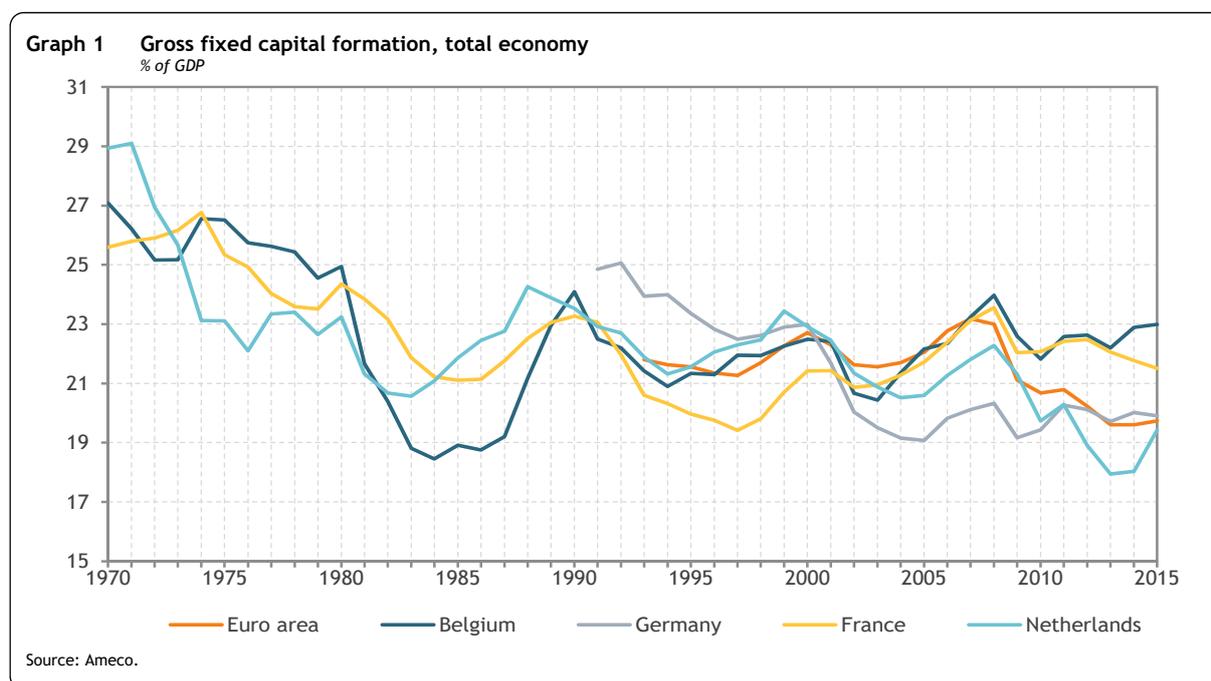
⁵ The asset 'Other structures' includes roads and railways; construction works for roads and railways (bridges and tunnels included), constructions and construction works for utility projects for fluids, for electricity and telecommunications, for water projects, for other civil engineering projects n.e.c., demolition and site preparation works and other specialized construction works.

energy and in water and waste management cannot be identified as such by lack of detailed data crossing industries and assets. This definition of infrastructure can underestimate transport infrastructure investments by not including public or private investments realized in other relevant assets such as non-residential buildings (railway stations...) or overestimate the infrastructure investment by including telecoms that are not linked to infrastructure. Even if this definition by assets has limitations, it seems more precise than an approach by industry, as proposed for example by the European Commission (2016a). Indeed, public investment, notably in roads, are classified either in Transportation and storage (HH) or in Public administration (OO) across Member States. Moreover, a non-negligible part of investment of these two industries are not infrastructure investment.

2. Evolutions and trend

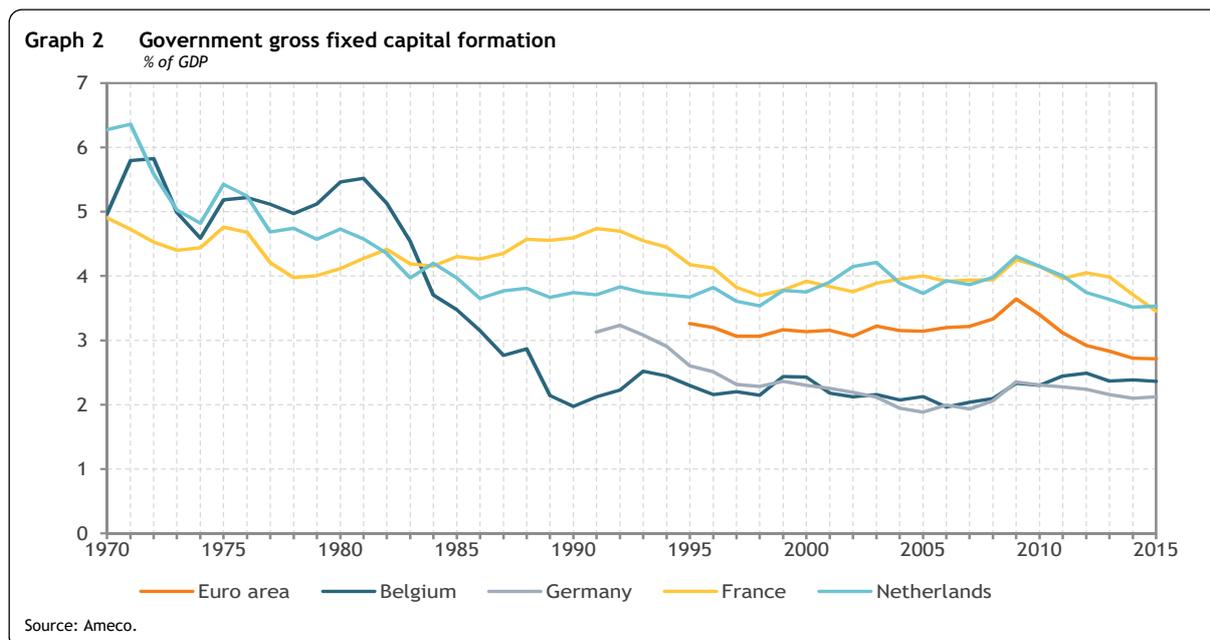
2.1. General government investment

Over the past 45 years, gross fixed capital formation for the whole economy as a percentage of GDP has been slightly decreasing in Belgium and in the neighbouring countries (Graph 1). While the private fixed capital formation rate was relatively stable, the government investment rate has been halved in Belgium since the beginning of the seventies (Graph 2). It amounted to 5.0% of GDP in 1970, against 2.4% in 2015. This strong decline occurred mainly in the eighties simultaneously with fiscal consolidation. Since the end of the eighties, the government investment rate stabilized, between 2% and 2.5% of GDP.



Due to this strong decline, the government gross investment rate in Belgium lags significantly behind the average of the Euro Area and the neighbouring countries, except Germany which records a government investment rate very close to the Belgian one. Nevertheless, over the most recent period, the lag between Belgium and the Euro Area has been reduced, due to a better resistance of Belgian government investment to the economic and financial crisis. In 2015, government gross investment rate reached 2.4% of GDP in Belgium, 2.7% on average in the Euro Area, 3.5% in France and in the Netherlands and 2.1% in Germany.

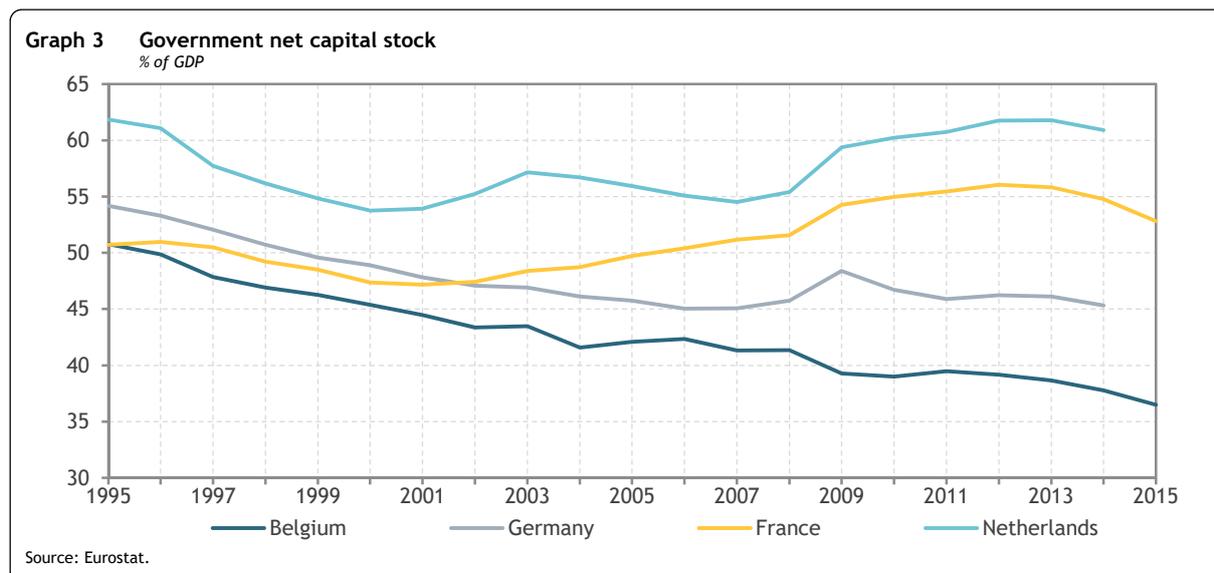
The international performance of Belgium concerning private gross investment was much better since Belgium recorded the highest private gross investment rate among the neighbouring countries over the recent period, 2006-2015. In 2015, private investment rate reached 20.6% of GDP in Belgium, against 17.8% in Germany, 18.1% in France and 15.9% in the Netherlands.



The strong decrease of government gross investment has impacted the government net investment defined as gross investment less depreciation. Since the beginning of the nineties, the net government investment rate has been very close to 0% being often even negative in Belgium, which is not the case in the neighbouring countries except Germany. That means that new investments were not always sufficient to compensate the wear and tear of the installed capital leading to a decrease in the net capital stock of general government (Graph 3). Since 1995, the government net capital stock of Belgium has decreased by almost 15 percentage points of GDP, reaching 36.5% of GDP in 2015. Germany recorded a similar evolution, but since 2006, its stock has stabilized. Starting from the same level as Belgium in 1995, France managed to slightly increase its stock over the period.

Data by categories of assets reveal that, in Belgium, the decline in stock of public capital in percentage of GDP is mainly explained by the decline in the category 'other structures'⁶ which notably includes roads, railways, and hydraulic works (-11.1 percentage points of GDP over 1995-2015) and non-residential buildings (-3.7 percentage points of GDP).

⁶ The asset 'Other structures' includes roads and railways; construction works for roads and railways (bridges and tunnels included), constructions and construction works for utility projects for fluids, for electricity and telecommunications, for water projects, for other civil engineering projects n.e.c., demolition and site preparation works and other specialized construction works.



2.2. Infrastructure investment

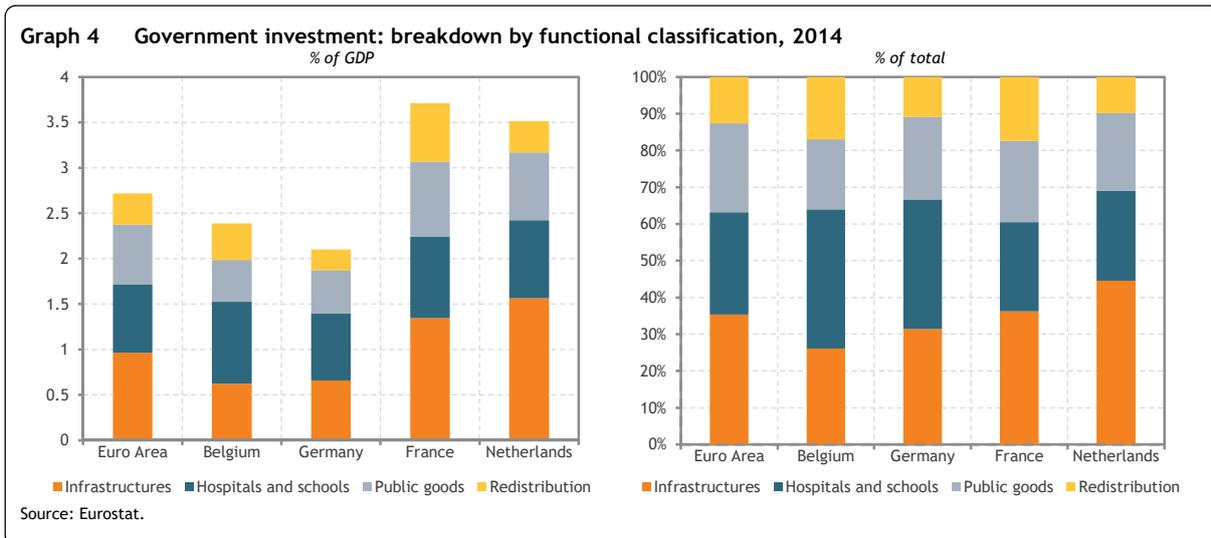
2.2.1. General government

Following Alegre et al. (2008) and Bom and Ligthart (2014), government investment can be broken down into four categories based on the functional classification (COFOG): infrastructure, hospitals and schools, public goods and redistribution (collective equipment, recreation, culture and social protection).⁷ It appears from Graph 4 that in Belgium, the relative importance of infrastructure in total government investment (26.1% of the total) was very low in 2014 in comparison with the neighbouring countries and the average of the Euro Area (35.4% of the total). The relative importance of hospitals and schools (37.9%) was, however, above the percentage observed in the comparison countries. These results are explained by the relatively high importance in the Belgian government investment of education, and particularly of tertiary education, and of basic research.⁸

In terms of investment as a percentage of GDP, government infrastructure investment reached 0.6% of GDP in Belgium in 2014, while it reached almost 1% in the Euro Area, 1.3% in France and even 1.6% in the Netherlands. Hospitals and schools investment reached 0.9% of GDP in Belgium, in France and in the Netherlands, slightly above the percentage in the Euro Area (0.8%) and in Germany (0.7%). The level of investment in public goods attained 0.5% of GDP in Belgium and in Germany, which was below the average of the Euro Area and of the Netherlands (0.7% of GDP) and of France (0.8% of GDP). Finally, redistribution investment reached 0.4% of GDP in Belgium, slightly above the percentage in the Euro Area, in the Netherlands, and in Germany.

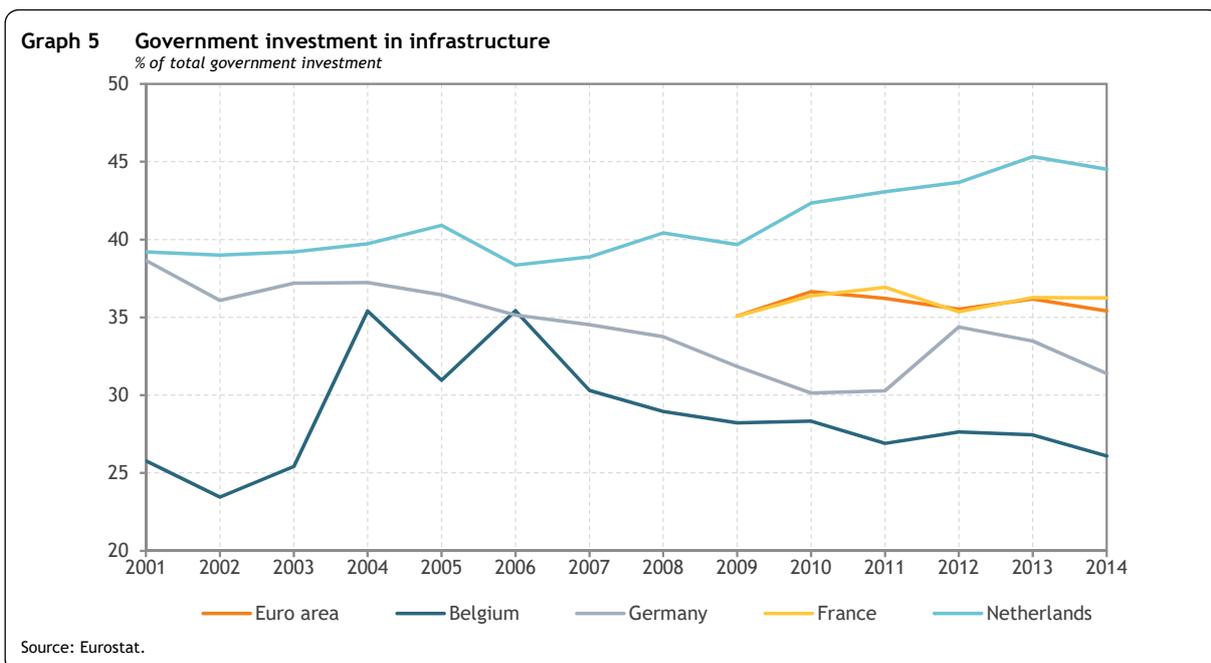
⁷ Compared with Alegre et al. (2008), the definitions of the classifications have been improved as a result of more detailed available data and the implementation of SEC2010. As mentioned in footnote 3, the definition of infrastructure is also an adaptation of Bom and Ligthart (2014) to the new ESA. The functional breakdown of government investment is provided at Annex A (Table A1).

⁸ Tertiary education comprises the levels 5, 6, 7 and 8 of the International Standard Classification of Education ISCED 2011, which are labelled as: 5. Short-cycle tertiary education (Hautes écoles/ Hogescholen), 6. Bachelor's or equivalent level, 7. Master's or equivalent level, and 8. Doctoral or equivalent level.



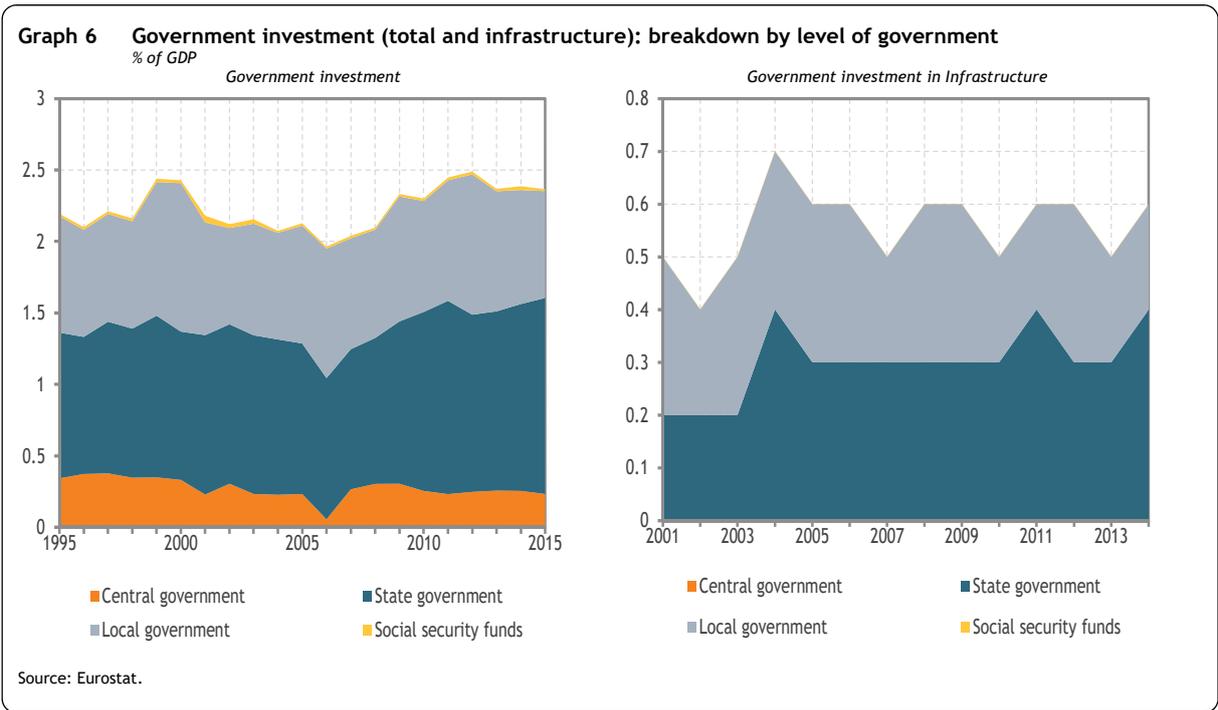
The share of the government investment devoted to infrastructure in total government investment was lower in Belgium than on average in the Euro Area or in the neighbouring countries over all the available period 2001-2014 (Graph 5). After an increase of 10 percentage points over the period 2001-2006, the Belgian share has steadily declined until 2014. In the Netherlands, the relative importance of infrastructure has increased over the whole period, from 39.2% in 2001 to 44.5% in 2014. By contrast, Germany also knew a decrease in the relative importance of infrastructure over the whole period.

The decrease in infrastructure investment in Belgium occurred at the benefit of government investment in hospitals and schools, which increased from 29.0% in 2001 to 37.9% of total government investment, thanks to education and, in particular, the jump in 2010 in tertiary education. The share of hospitals and schools investment also increased in the other countries over the period 2001-2014. The share of investment in public goods decreased from 30.2% of total government investment in 2001 to 19.1% in 2014 in Belgium. Finally, the share of redistribution was more stable.



Government investment in infrastructure mainly consists of investment in transport. In Belgium, investment in transport represented 88.4 % of infrastructure investment in 2014, which is significantly above the percentage of the Euro Area (63.3%) and of each neighbouring country. The share of transport in infrastructure investment has significantly increased since 2001 in Belgium, when the share attained 69.2%. This happened at the expense of waste water management which decreased from 24.2% of infrastructure investment in 2001 to 4.2% in 2014.

The breakdown of government investment by level of government (Graph 6) shows that, during the past twenty years, government investment has been mainly carried out by state governments (in the Belgian context the Regions and Communities) and by local governments. More than 85% of government investment is concentrated at these two levels. The state governments are in particular responsible for a part of the road network, for education and for basic research. Investments of local governments are more widespread across the different functions due to the various areas that fall under their competencies. Local authorities invested particularly in the areas of transport, as they are responsible for the local road network, and of redistribution (particularly in social protection and recreation, culture and religion). These two levels of government are responsible for about 98% of government investment in infrastructure. The federal government concentrated its investment on public goods (in particular, on military defense, general public services, and to a lesser extent on public order and safety).⁹

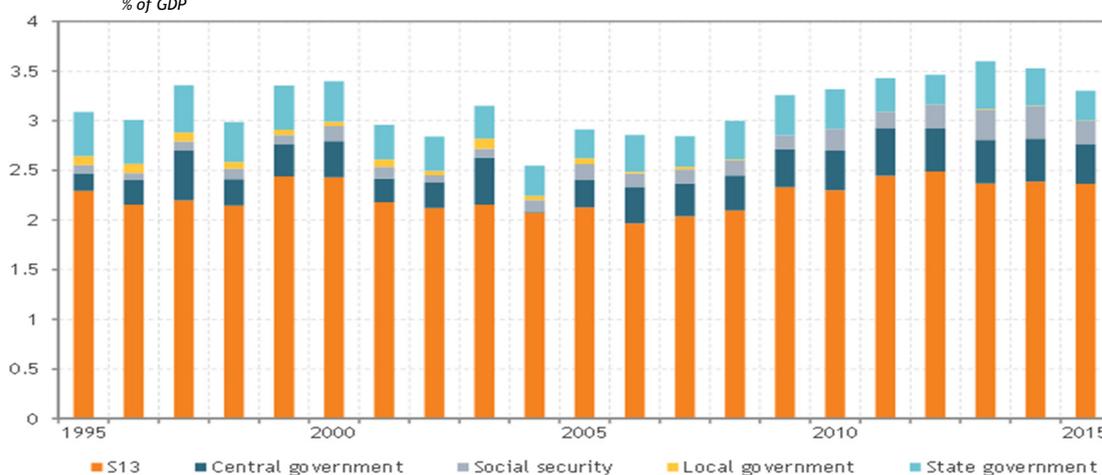


⁹ Investment by level of government and by type of investment are available in Annex A (Table A2).

Box 3 Investment grants and capital transfers in infrastructure

As already mentioned, all entities controlled by government are not statistically classified in the General government sector S13. However, when assessing public sector investment in broad terms, these entities have to be taken into account. Their investment is not easily identified in national accounts and has to be estimated. Investment aids (D92P in national accounts) from the government sector granted to non-financial corporations sector (S11) can be used as a proxy but should be interpreted with caution. Although investment aids from the central government (almost exclusively to the NMBS/SNCB) are granted to entities classified in S11 but controlled by government, it is not necessarily the case for investment aids from other levels of government. Local governments and state governments (Regions and Communities) also give grants to private businesses. Consequently, for these levels of government, public investment estimated by this proxy is overestimated. Taking this caveat into account, “public investment” might increase so far as 3.3% of GDP in 2015, against 2.4% for the General government investment (S13)¹. This broader definition could modify the breakdown of public investment by functional classification and consequently the importance of infrastructure in total public investment. However, it does not allow investment of the public sector to recover the level observed during the seventies.

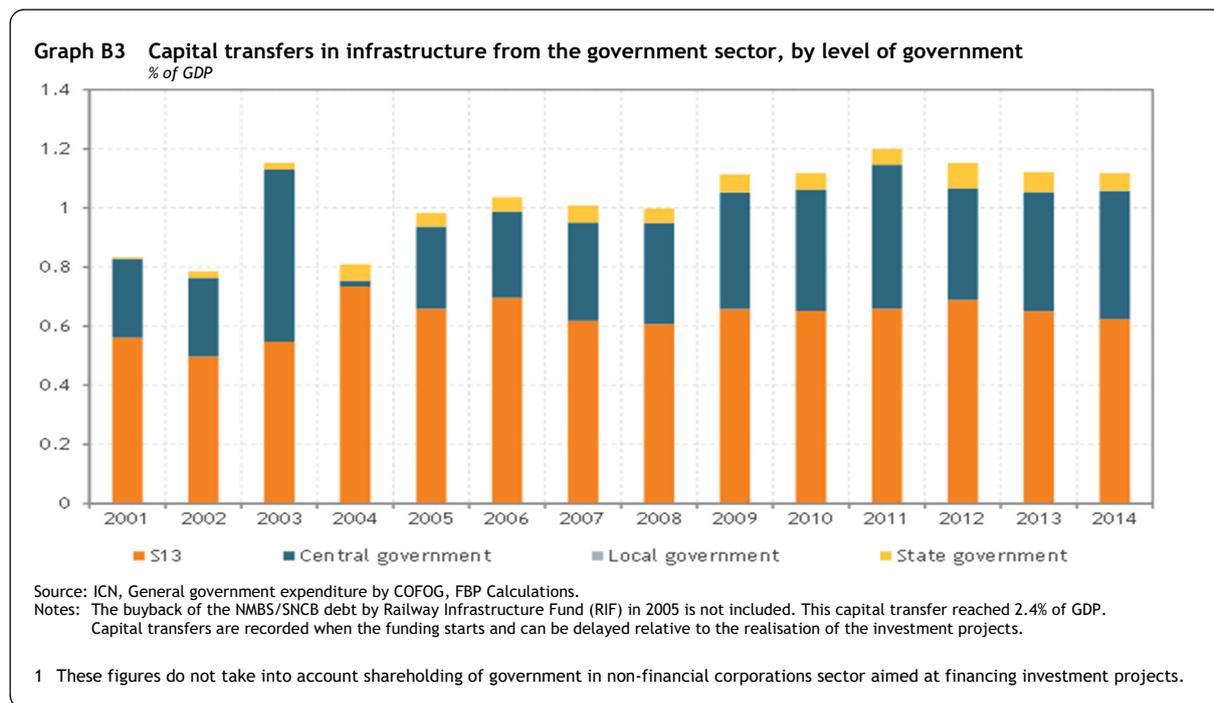
Graph B2 General government investment (S13) and investment grants from the government sector, by level of government
% of GDP



Source: ICN, FBP Calculations.

Note: Investment grants are recorded when the funding starts and can be delayed relative to the realisation.

A broader definition of Public investment in infrastructure could also be estimated by using data on capital transfers (D9P) in infrastructure (based on COFOG classification as defined by Bom and Ligthart (2014)) from the government sector S13. However, available data include all transfers from the government sector to all other sectors, and not only to non-financial corporations (to which the entities controlled by government belong). Public investment in infrastructure is consequently overestimated. According to this estimation, public infrastructure investment could reach 1.1% of GDP in 2014, against 0.6% of GDP for the general government investment (S13) in infrastructure, see Graph B3.



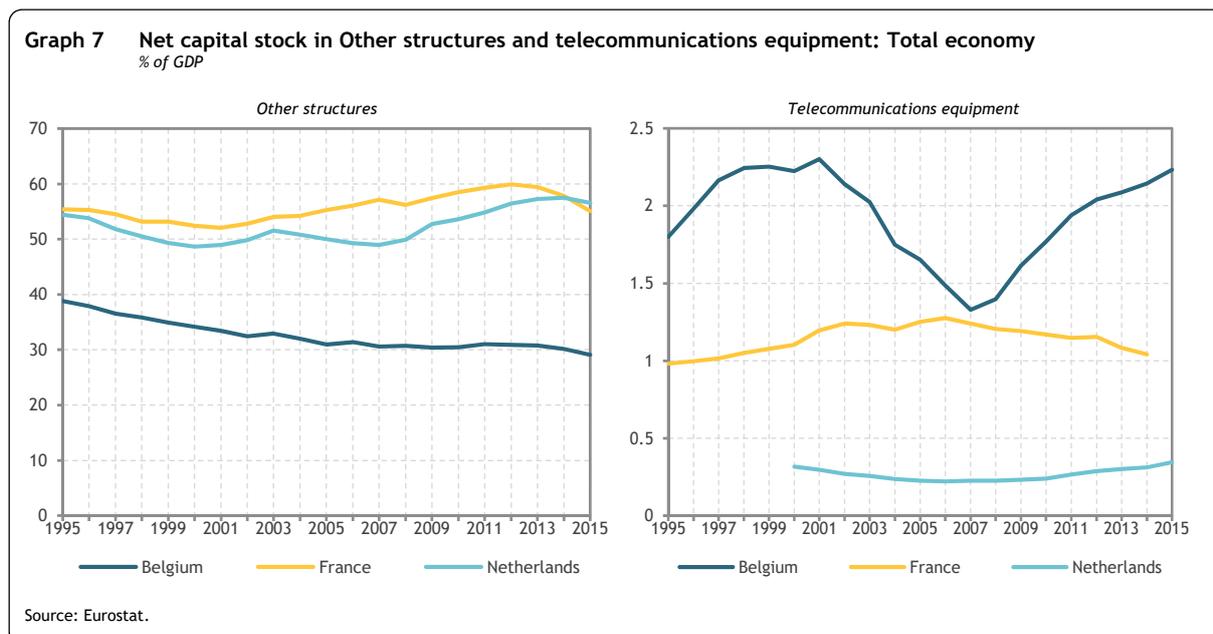
2.2.2. Whole economy

According to our definition, Graph 7 provides, for the total economy (private and public sectors), the net capital stock of other structures and telecommunications equipment.

It appears from Graph 7 that, over the whole period, the net capital stock of other structures was particularly low in Belgium compared to the stock in the two other countries for which data are available.¹⁰ Moreover, contrary to the evolution observed in France and in the Netherlands, the net capital stock of other structures in Belgium experienced a deterioration over the last 15 years by decreasing by almost 10 percentage points of GDP. Data by institutional sector show that the government sector was responsible for this decrease since the net capital stock of private sector slightly increased in percentage of GDP over the period (+1.9 percentage point for the sector of non-financial corporations).

In percentage of GDP, the net capital stock of telecommunications equipment in Belgium was significantly above the net capital stock of France and the Netherlands over the whole period. The level of the net stock in Belgium fluctuated between 1.4% of GDP in 2008 and 2.2 % of GDP in 2015. In the two other countries, the evolution of the net stock was more stable, around 1% of GDP in France and 0.3% of GDP in the Netherlands. The figures have however to be interpreted with caution given the fact that all investment in telecommunications equipment are not infrastructure investment.

¹⁰ Data for Germany are not available.



To sum up, general government investment has decreased in Belgium since 1970 from 5% of GDP to 2.4% in 2015, whereby the largest fall occurred in the eighties. Ever since, gross investments were not always sufficient to compensate for the depreciation of the installed capital leading to a decrease in the net capital stock of general government in percentage of GDP. Since 1995, the government net capital stock of Belgium has decreased by almost 15 percentage points of GDP. Even when a broader definition of public investment is taken into account by including investment aids from the government sector to non-financial corporations, public investment does not recover the rate reached in the seventies.

From an international perspective, the Belgian government investment rate (2.4% of GDP) lags behind the average of the Euro Area (2.7%) and the neighbouring countries, except Germany.

The government investment rate in Belgium has not only decreased since the seventies but its composition has changed at the expense of infrastructure. In 2014, government infrastructure investment reached 0.6% of GDP in Belgium compared to almost 1% in the Euro Area, 1.3% in France and even 1.6% in the Netherlands.

3. Channels of transmission

An increase in government investment could, depending on the initial conditions, yield a double dividend: a positive impact both on short-term growth via aggregate demand and on long-term growth through its impact on the supply side of the economy.

In textbooks, an increase in government investment leads, in the short run, to a positive impact on GDP greater than the initial investment increase due to the government investment multiplier.¹¹ However, the value of this multiplier depends on the nature of the investment and on the mode of financing. The nature of the investment determines the extent of the positive impulse on the economy, in function of the share of this expenditure covered by domestic production rather than by imports. For instance, the construction of a new public building has a greater positive impact on the domestic economy than the purchase abroad of military equipment. Concerning the financing, three options are basically available: an increase in taxes, a decrease in other government expenditures or an increase in public debt. The increase in taxes reduces income of the private sector and therefore has a negative impact on growth, giving rise to a lower multiplier. The reduction in other government expenditures has also a negative effect which could be even larger than the initial positive effect depending on the category of public expenditures reduced. Debt financing does not present this negative impact. However, depending on the financing conditions and the response of monetary policy, this increase in investment could also translate into an increase in the interest rate, crowding out private sector investment. Eventually, the increase in income in response to a government investment expansion is smaller than the one expected with the basic Keynesian multiplier. This positive effect could even be more limited by the implication of the Ricardian equivalence. According to this assumption, government debt is equivalent to future taxes and if consumers are sufficiently forward-looking, future taxes are equivalent to current taxes. The implication of the Ricardian equivalence is that a debt-financed government investment increase leaves households' consumption unaffected with respect to the situation where the increase in investment is financed with higher taxes. The increase in private savings exactly offsets the decrease in public savings. National saving remains the same. Opponents to this view argue that current income is more important than lifetime income for those consumers who face binding borrowing conditions.¹² This argument reintroduces the possibility of a positive effect on consumption of government investment increase depending on the share of households who are credit/liquidity-constrained.

In the long run, an increase in government investment also impacts aggregate supply. Firstly, because when operational, this investment increases the capital stock and therefore the production capacity of the public sector. As at least part of this production is recorded in GDP as measured by national accounts, GDP increases. Secondly, part of government investment can improve the total factor productivity (TFP) of private firms increasing the production capacity at the steady-state. An example of this TFP impact is the improvement of transport infrastructure allowing private firms to exchange their products more rapidly and more safely. This saving of time is also a saving of production costs that is

¹¹ A multiplier is defined as the factor by which gains in GDP are greater than the change in spending that caused it. In its most basic form, the value of the multiplier is positively dependent on the marginal propensity to consume.

¹² Moreover, the certainty to die at an unknown moment may make the value of current consumption outweigh the burden of future taxes even when credit conditions are not binding.

captured by the residual component of labour productivity growth, the total factor productivity. This increase in TFP also enhances private sector capital productivity encouraging more investments by private firms. In this case, an increase in government investment crowds in of private investment. Some government investments such as investment in R&D or in education might also have a direct impact on the innovation capacity of the economy (also measured by TFP) as R&D creates knowledge which cannot be fully appropriated but diffuses through all sectors. Such investments have also an indirect impact as they reinforce the absorptive capacity of the economy. Indeed, to be able to capture outside innovation, a firm needs to already own a certain level of knowledge which can be strengthened by government investment in R&D and education.

While many empirical studies confirm the positive relationship between government investment and GDP growth, they offer a wide range of values for these elasticities.¹³

Seminal studies, such as Aschauer (1989ab), found a large public-capital elasticity of output, between 0.34 and 0.39, but suffered from rudimentary statistical techniques that did for example not take care for endogeneity. Munnell (1990) analysed the relationship between public capital stock and economic activity at the state-level in the United States. She estimated production functions for the states and found that public capital had a significant positive impact on output but that the output elasticity was roughly one-half the size of the national estimate (0.15 at state level versus 0.34 at national level). However, her approach suffered from the same methodological limitations as previous works did.

By adequately coping with econometric issues in later studies, the estimates have tended to become lower (Sutherland et al., 2009). Still, there is a large variation in estimates. Varga and In 't Veld (2010, p. 19) blame this on "econometric problems relating to common trends, missing variables, simultaneity bias and reverse causation". It made some even conclude that studies building on a production function are of little use for policy analyses (Varga and In 't Veld, 2009b).

The role of econometric and data issues was confirmed by Bom and Ligthart (2014). They did a meta-analysis explaining the variation in estimates of elasticities. From 68 studies, they built a sample of 578 estimates, 80% being positive and 20% negative. For sake of comparability, they only included studies using monetary measures of public capital. They controlled for investments in infrastructure versus government investments in general. The sample covered the period 1983–2008. The simple average elasticity was 0.188. The standard deviation was 0.306, reflecting the wide variation among the estimates. The range of these estimations was explained by differences in sampling and econometric modelling. The estimated average elasticity was 0.106. The long-term elasticities also differed according to the nature of the investment and the level of government implementing this investment.

Studies estimating cost- or profit function instead of production function parameters, found in many cases that public capital reduces costs and/or increases profits. There are, however, questions about the magnitude of the effects. Straub and Tchakarov (2007) note that the impact is relatively weak. According to Wang (2002), many studies found significant cost savings resulting from the provision of public infrastructure services.

¹³ The output elasticity of public capital measures the percentage change of output generated by a change of public capital of 1%.

Many studies made since the early 1990s controlled for endogeneity.¹⁴ Indeed, if more infrastructure could sustain growth, more growth could lead to more infrastructure required by the expansion of the activities, potentially causing biased estimates when unaccounted for.

Certain studies confirm the existence of non-linearity, but both progressive and degressive relationships were found. Generally, it is assumed that the better the infrastructure is developed, the weaker the marginal impact of new investments may be. This is confirmed for OECD countries by Égert et al. (2009), who interpreted negative coefficients to indicate overinvestment. To the contrary, the impact of network externalities found by Röller and Waverman (2001) made them conclude that the non-linearity could be progressive. They suggested that there might be a critical level of telephone penetration that is needed for economic growth to materialise more effectively.

Finally, the impact of certain conditions on the extent of the effect was confirmed by Abiad et al. (2015). They found the effect to depend on the degree of economic slack, the efficiency of government investment and the way of financing. The efficiency of government investment was also an important issue for Wang (2002). He saw it as one of the explanations of the insignificance of the marginal productivity of infrastructure capital in most of the South-East Asian countries he analysed. His outcomes also suggested that the efficiency would be higher in more advanced economies.

Empirical analyses are thus inclined to confirm the positive impact of public capital upon output growth and the reduction of production cost. The estimated strength of the impact, however, varies widely among studies and seems to depend on data sampling and econometric issues. Still, the impact of infrastructure investment seems to be stronger than the impact of other types of government investment. Furthermore, there is evidence of a non-linear relationship, weakening the impact when an optimal level of infrastructure is approached.

¹⁴ E. g. Röller and Waverman (2001), Wang (2002), Esfahani and Ramírez (2003), Pradhan and Bagchi (2013) and CEC (2014).

4. The QUEST model

It has been shown above that the positive relationship between public capital and economic growth has been established empirically. However, such an empirical estimation – though meaningful – is partial. Economic models are more comprehensive and complement the empirical estimation. They comprise a large set of economic variables and their interrelationships. The latter include all relevant causal mechanisms as drawn from economic theory and partial analyses. This way, the model enables to simulate the impact of a policy measure or other predetermined change, not only on GDP (the typical dependent variable in observational studies), but also on other variables such as the employment rate, the government budget and private consumption and investment. This shift from observation to hypothesis comes at a risk, however. Theorised causalities may be wrongly specified and results may be unduly generalised. With these caveats in mind, the next section explores the impact of an increase in government investment on the Belgian economy. It does so by applying the European Commission's general-equilibrium model QUEST, described in this section.

There are several classes of models. General-equilibrium models make the fundamental assumption that the economy strives, at least in the long term, towards a state in which prices and wages have adjusted such that all markets (i.e. product, labour, financial markets) clear. The process of self-adjustment corresponds to what Adam Smith called 'the invisible hand'. A merit of these models is that they can account for causal relationships between economic variables that have not (yet) shown up in macroeconomic time series because of unavailability of data or lack of precedent, but which are well established in microeconomic research. These models are also expected to predict more accurately a correction in the face of an unsustainable incongruence in the system, e.g. an unbalanced government budget. A drawback is that the economy may not be modelled in a very detailed way, and the mechanisms at work may rather be theoretical constructions – though sensible ones – than established relationships. Computational limitations may also affect these models' level of detail, e.g. by necessitating to work with representative households and firms and oversimplified policy rules. An alternative class of models is that of the structural-econometric models. These models contain a detailed representation of the economy, based on empirically measured relationships. However, they are often demand driven, thus lacking the TFP-enhancing supply-side channel introduced in the previous section. Moreover, they may not simulate structural change.

In the economic literature, there are many other examples of general-equilibrium models simulating the economic impact of infrastructure investment. They come from both academic and (inter)national institutions, such as the ECB and the IMF. Given the fact that QUEST contains a Belgian version consisting of three connected economies (Belgium, the rest of the Euro Area and the rest of the world), allowing for simulations tailored to the Belgian policy environment, it was considered the most appropriate choice for the current exercise. Annex B summarily introduces the models used at the ECB and the IMF, along with some other models, to emphasize the variety of ways in which basic economic relationships are modelled in practice.

This section gives a brief introduction into QUEST. It introduces the economic sectors modelled, and some of the crucial transmission channels. Some calibration issues in the context of the current exercise are also discussed.

4.1. Model description

The dynamic stochastic general equilibrium (DSGE) model QUEST has been developed by the Directorate General for Economic and Financial Affairs of the European Commission for a wide variety of policy analyses, leading to the existence of several versions. A comprehensive introduction to QUEST III is given by Ratto et al. (2008).¹⁵ For the analysis of structural reforms, Roeger et al. (2008) extended that model to include human capital accumulation and endogenous R&D. It captured both investment in tangibles and intangibles, but did not yet explicitly model government investments. That has been done by Varga and In 't Veld (2009ab, 2010) in a series of studies on the economic impact of the cohesion policy. A later version of this model has been used to assess the spillover effects of public investment in surplus countries (In 't Veld, 2016). For the simulations presented below, a recent update of the model is used. As stated earlier, it covers three interdependent regions: Belgium, the rest of the Euro Area and the rest of the world. It is recalibrated with 2015 national accounts data.

Four economic sectors interact: firms, households, government, and the foreign economy. There are three kinds of *firms*: firms producing intermediate goods, firms producing final goods, and R&D firms producing designs for new varieties of intermediate goods. The former two kinds operate in a monopolistically competitive environment. This implies that their products are not homogenous. Each producer makes its own unique variety and competes against the varieties of other producers. Still, this market structure gives rise to a certain level of market power, which allows for above-cost pricing. Imperfect competition and above-cost pricing can thus be accounted for in the model, as well as the effects of counteracting policy measures.

There are two kinds of *households*: households with liquidity constraints and households with no liquidity constraints. The former group is tied to consume all their income during the current period. The latter group participates in equity and bond markets and owns physical capital and the patents on the designs produced by the R&D firms. They may thus anticipate future developments, on which they have perfect foresight. This implies that financing a policy measure by taxes or by government debt has the same effect on consumption for these households (i.e. Ricardian equivalence). In reality, an increase in government debt is observed to generate some but no full anticipation of a future tax raise among taxpayers. Hence, the proportion of the two types of households in the model is set to reproduce the observed degree of anticipation. In section six, a sensitivity analysis for this proportion is done.

The *government* sector carries out fiscal and monetary policy, the former at the national and the latter at the Euro Area level. Fiscal policy is based on a target debt-to-GDP ratio, be it the 60% target of the Stability and Growth Pact (SGP) or any other modelled target. When the actual debt deviates from the target, the model launches a fictitious debt-controlling tax. This is a stylized, gradually imposed head

¹⁵ The models of the DSGE class are dynamic in the sense that the variables are related across time periods, for example making current outcomes dependent of future expectations. They are stochastic in the sense that they allow for a variety of shocks, such as demand, supply, monetary-policy and cost-push shocks.

tax enforcing convergence to the debt target and hence quantifying the effort to reach this target. A Taylor rule instated at the Euro Area level defines monetary policy. In brief, the monetary authority makes the short-term interest rate partly dependent on inflation and on the output gap. Overheating or slack are thus dealt with by appropriate changes of the interest rate.

Given this model's structure, a positive shock to government investment is transmitted as follows. In the short run, it adds to aggregate demand. It is initially financed through an increase in government debt. This is compensated for by gradually raising the debt-controlling head tax, tending towards budget-neutral financing at the end. Public investment thus diverts spending from the private sector to government. However, it also adds to public capital, which contributes to the productivity of the final goods sector which leads to real wages increase.¹⁶ Subsequently, private consumption also rises. The demand impulse given by the public investments may still be inflationary, as is the case for a government consumption shock. However, it is probably less strong due to the increased productivity induced by the increase in potential output. The demand for government investment goods is mainly satisfied through domestic production. Still, part of it directly and indirectly leaks away via imports. Eventually, exports benefit from the reduced domestic inflationary pressure.

4.1.1. The supply-side channel: public capital and output

In the 2016 version of the model, which is used for the simulations below, public capital KG_t enters as a TFP-enhancing input in the production function of the final goods producing industry:

$$Y_t = PAT_t^{\frac{1-\alpha}{\theta_{RD}}} IX_t^{1-\alpha} L_t^\alpha KG_t^{\alpha_G} - FC_Y \quad (1)$$

The production technology is of the Cobb-Douglas type with the output elasticity of labour equal to α , but reduced by a fixed cost FC_Y . The input factors are labour L_t , private tangible capital supplied by intermediate firms IX_t , a measure of private intangible capital PAT_t , and public capital KG_t . The gross quantity $Y_t + FC_Y$ displays constant returns to scale in labour and private capital per intermediate firm, but increasing returns to scale if public capital is included.¹⁷ PAT_t represents the state of technology. It depends on the output (number of designs) of the R&D sector and is normalized to 1 in the initial, pre-shock equilibrium. Increasing R&D results in more intermediate varieties, which leads to increased productivity in the final sector. Price-cost mark-up $1/\theta_{RD}$ is the operator for market power in the intermediate sector. It negatively depends on the elasticity of substitution between varieties.¹⁸

¹⁶ The wage determination in QUEST is stylized and therefore does not take into account the particularities of the Belgian wage forming system (e.g. law of 26 July 1996 on the promotion of employment and the safeguarding of competitiveness).

¹⁷ Under constant returns to scale (CRS), output is proportional to labour and capital. When the latter two grow at the same rate, output will grow at that rate too. Under increasing returns to scale (IRS), output would grow at a higher rate. In the mathematical representation of (1), CRS in labour and capital is reflected by the fact that their elasticities sum to 1. The elasticities show the sensitivity of output to changes in the utilisation of those primary production factors. Under IRS, the sum of elasticities exceeds 1. In (1), this is accomplished by the inclusion public capital and its elasticity α_G .

¹⁸ A high elasticity of substitution indicates that the varieties at hand are close substitutes. In that case, producers are more prone to competition. They have limited opportunities to exploit market power, which makes them have relatively low price-cost mark-ups.

Note that these definitions imply that total private tangible capital K_t equals $K_t = PAT_t IX_t$. Total factor productivity (TFP), following its usual interpretation as the production residual after private capital and labour are accounted for, can then be expressed as:

$$TFP_t = PAT_t^{(1-\alpha)\left(\frac{1-\theta_{RD}}{\theta_{RD}}\right)} KG_t^{\alpha_G} \quad (2)$$

which shows that public capital indeed enhances TFP.

As argued in section three, there is a positive long-term relationship between infrastructure and economic growth, reflected by output elasticity α_G . From (1), extension of the public capital stock – be it in quantity or quality – allows for more output to be produced at a given level of labour and private capital. This makes their productivity rise, inciting producers to hire more of both and/or raise their remuneration. The production function does not allow for non-linearity, since α_G in (1) is fixed. This implies that it does not change at increasing or decreasing KG_t . It does also not correct for possible inefficiencies in the deployment of public investments.

The stock of public capital is subject to depreciation at rate δ_G , but augments by government investments IG_t :

$$KG_t = (1 - \delta_G) KG_{t-1} + IG_t \quad (3)$$

Government investments are endogenous, which means they are determined inside the model. They depend on the level of output, and their growth depends on economic growth. Nominal government investments are set as a fixed percentage IGS_t of nominal GDP:

$$PC_t IG_t = IGS_t GDP_t PGDP_t \quad (4)$$

where GDP_t represents real GDP, $PGDP_t$ is the price deflator, and PC_t is the consumer price. The latter price is a CES aggregate price level based on $PGDP_t$ and the import prices (PIM_t , see below).¹⁹ It serves as the deflator for IG_t since part of the concerned investment goods is produced domestically and part is produced abroad.

The shock to be simulated takes the form of a predetermined – or exogenous – increase of IGS_t in (4). It thus makes the public capital stock of (3) grow more strongly than in the baseline.

4.1.2. Fiscal and monetary policy

Fiscal policy is based on a target debt-to-GDP ratio b^T . Public debt has the following general structure:

$$B_t = (1+r_t)B_{t-1} + G_t + IG_t + TR_t - R_t^G - T_t^{LS} \quad (5)$$

¹⁹ CES = constant elasticity of substitution.

The terms on the right-hand side represent, respectively, the previous period's debt augmented with interest payments $(1 + r_t)B_{t-1}$, public consumption G_t , public investment IG_t , social security transfers TR_t , government revenues R_t^G (including taxes on consumption and labour and capital income) and the fictitious debt-controlling head tax T_t^H .²⁰ The latter is imposed gradually and follows the rule:

$$\Delta T_t^H = tgov^{B1} \left(\frac{B_t}{GDP_t} - b^T \right) + tgov^{B2} \Delta \left(\frac{B_t}{PGDP_t} \right) \quad (6)$$

The periodical adjustment is partly sensitive to the deviation of the ratio of public debt to nominal GDP from its target b^T , and partly to the actual change in real debt $\Delta(B_t/PGDP_t)$. The basic simulation in the next section will follow this debt-controlling tax scheme. Some alternative and more realistic financing mechanisms are also investigated.

The default model thus holds a hybrid financing mechanism. A shock to public investment initially results in the debt target being exceeded. This will then be compensated for by gradually raising the head tax on households by rule (6). Hence, there is a tendency towards budget-neutral financing in the long term. Government investment thus diverts spending from the private to the public sector. The economy, however, still benefits from the higher productivity induced by the expanded public capital stock. In theory, it is possible that the increase in GDP is so large that it actually pushes the debt-to-GDP rate down even though government expenditure in absolute terms has risen due to the shock. This so-called 'fiscal free lunch' would result in a negative head tax, so a head transfer.

Monetary policy is based on a Taylor rule. In the Euro Area, it is the responsibility of the ECB. In QUEST, the Taylor rule is assumed to take the aggregate Euro Area inflation and output gap into account:

$$i_t = \rho^{LAG} i_{t-1} + (1 - \rho^{LAG})(r^* + \pi^T + \rho^{INF}(\pi_t - \pi^T) + \rho^{YGAP} Y_t^{GAP}) \quad (7)$$

The nominal interest rate i_t does not change instantaneously, but with a time lag dependent on the exogenous parameter ρ^{LAG} . Given this time lag, it is determined by the equilibrium real interest rate r^* , the target inflation rate π^T , the deviation of actual Euro Area consumer price inflation π_t from the target, and the Euro Area output gap $\rho^{YGAP} Y_t^{GAP}$. The latter is defined as the deviation of capital and labour utilisation from their long run trends (Lorenzani and Varga, 2014). In the prevailing context of very low interest rates, QUEST allows for an exogenous floor interest rate. When i_t would fall below the floor – which is set at zero – the latter will hold:

$$\bar{i}_t = \max(i_t, i^{FLOOR}) \quad (8)$$

Note that the variables of (7) and (8) do not represent the national, but the Euro Area level.

²⁰ Varga and In 't Veld (2009ab, 2010) and Lorenzani and Varga (2014) apply slightly different specifications which are adapted to the purposes of their analyses. They separated unemployment benefits being indexed to wages, while other transfers were made proportional to GDP. Varga and In 't Veld (2009ab, 2010) explicitly modelled cohesion policy by transfers among Member States. Lorenzani and Varga (2014) explicitly modelled subsidies on capital and R&D investments.

4.1.3. The demand-side channel: consumption, investment, and current account

Besides the supply-side channel, government investments are transmitted via the demand-side channel. In the short run the investments add to aggregate demand. In QUEST, the resource constraint of the economy takes the following form:

$$Y_t = \left(\frac{PC_t}{PY_t}\right)^\sigma \left(\frac{s}{2-s}(C_t + I_t) + \frac{1-sg cim(1-s)}{2-s}G_t + \frac{1-sigim(1-s)}{2-s}IG_t\right) + \frac{EX_t}{2-s} + TRACO_t \quad (9)$$

where Y_t and PY_t denote final goods production and price, and C_t , I_t , G_t , IG_t and EX_t stand for private consumption and investment, public consumption and investment, and exports, respectively. $TRACO_t$ covers a range of transition costs related to changes in nominal wages, employment and private investment. The equation is derived from the standard macroeconomic resource constraint, in which imports have been substituted. The steady state import equation takes the form:

$$IM = \left(\frac{PC}{PIM}\right)^\sigma (1-s)(C + I + sg cim G + sigim IG + Y) \quad (10)$$

where IM denotes imports and PIM import price. σ represents the elasticity of substitution between imported and domestically produced goods. s is a measure of how closed an economy is towards imports, taking values between 0 (everything is imported) and 1 (nothing is imported). The inclusion of final sector output in the formula for imports is meant to introduce intermediate imports into the model.

Since $PIM = PC = 1$ in the initial, normalized equilibrium, and $(1-s)$ can be calibrated by the observed fraction of imports in the economy, $sigim$ can be used to calibrate the direct import leak in public investment $(1-s) sigim$, which amounted to 20,2% in 2010. Due to model restrictions, s and $sigim$ together also determine the indirect import leak in the model, at 45,6%. This is not far from the observed value of 42,1%.²¹

Hence, when simulating an increase in government investment IG in QUEST, the magnitude of the original shock is diminished by the factor $\frac{1-sigim(1-s)}{2-s}$ to take into account both the direct and indirect (intermediate market) import leaks.

In the short run, private sector output Y_t will not be able to adjust to increased demand because production in the model is dependent on public capital and the other primary factors given in production function (1). It takes time for the supply of these production factors to adjust to the increased demand because of transition costs. This implies that either other demand components (private consumption or investment, government consumption or exports) have to decrease relatively, and/or the domestic final goods price has to increase relatively to the consumer price.

²¹ Source: Input-Output Tables, Federal Planning Bureau.

4.2. Adaptation of the QUEST model: calibration issues

4.2.1. Elasticity of output

One critical element of the analysis of public investments is the elasticity of output with respect to public capital. This parameter (α_G of production function (1)) cannot be observed directly. In QUEST III, it was calibrated at 0.09. The economic literature gives a wide variety of estimates, but ample attention is nowadays paid to the meta-regression results of Bom and Ligthart (2014). Based upon the estimated model of these authors, α_G was set at 0.12. This choice builds on the following considerations. It covers all public capital at the national and state level. It controls for the business cycle, which Bom and Ligthart (2014) proxied by a dummy indicating the presence of energy prices as an explanatory variable in their sample of studies. It has a focus on the long term. It is matched to three major neighbouring countries rather than the US as it is often done in simulation exercises. In Bom and Ligthart (2014), the country dummy for Belgium was insignificant due to lack of data points (too few studies include Belgium). Since the country effects of the neighbouring countries did not differ too much, their GDP-weighted average was considered a reasonable proxy for Belgium.

4.2.2. Starting value of public investment and debt-to-GDP ratio

Other critical elements of the model concern public finance. In the Belgian calibration of QUEST III, the share of public investments in GDP is 2.77%. This is higher than the share given by national accounts, which cradled between 2.3 and 2.5% during the past years as illustrated in section two. For the simulations, it was lowered to 2.36%, the observed value of 2015. The government debt was also higher than emerging from current data. The initial debt-to-GDP ratio and its long-run target were 114.9%. For the simulation, both were fine-tuned to 105.8%.

4.2.3. Labour supply parameters

Some labour supply parameters were adapted as well. First, the wage replacing benefits were chosen to evolve proportionally to the consumer price index rather than to wages, which is closer to the Belgian situation. Second, the labour supply elasticities were differentiated along skill levels, as Mastrogiacomo et al. (2013) estimated on the Dutch economy. From this study, the average elasticity for singles over 4 different specifications was taken. The value derived for the higher educated was used for the high skilled labourers in QUEST III, while the value derived for the lower educated was used for medium and low skilled labourers. Finally, the parameter CSEARCH, which is a function of the proportion of the change in the unemployment rate due to a rise in after tax wages with respect to the change due to a decrease in unemployment benefits, was redefined to match the value of 2.33 found in Bassanini and Duval (2006). In Section 6, a sensitivity analysis will be performed on this variable.

4.2.4. Other variables

Further significant fine-tuning was made to private investments, the private capital stock, R&D intensity, imports, and exports. Note that the model assumes that trade is balanced in the initial equilibrium. Relatively small fine-tuning and updates were made to certain other labour-market variables than discussed above, such as employment rates, non-participation rates, nominal and real wages, and population shares by education level. The review of calibration data was not limited to Belgium. It covered the same variables at Euro Area level. The equivalent variables for the rest of the World were left unchanged.

5. Simulations

5.1. Basic simulation of a government investment increase

The shock of public investment in the basic simulation amounts to 0.5% of GDP, or about 2 billion euros per year, immediately and permanently lifting the share of government investment from 2.36% to 2.86% of GDP. While the simulation mainly serves to illustrate what a significant uptake of government investments may mean for the economy, it is also in line with the need for infrastructure investments identified in the context of the Investment Plan for Europe (IPE, see Box 4). In 2014, the Member States, the European Commission and the European Investment Bank (EIB) held a 'Special Task Force on Investment in the EU' as part of the preparation of the IPE. It took stock of the potential for the IPE by listing projects that could be eligible for the financing scheme. The Belgian contribution consisted of 162 projects with a total amount of 77 billion euros. Among the 162 projects, 44 concerned public infrastructure. These included motorways, secondary roads, railways, urban public transport, seaports, inland navigation, renewable energy and high-speed data networks. They represented an investment of 35.2 billion euros. When it is assumed that the development and completion of the projects will take 15 years, this implies an amount of 2.3 billion euros per year on average, which is 0.57% in terms of 2015 GDP. Following these data, the investment shock of 0.5 percentage points of GDP seems therefore reasonable. It may even be considered prudent since government investment other than infrastructure is also embodied in the shock.

Box 4 *The Investment Plan for Europe*

In 2015, the European Commission (EC) launched the Investment Plan for Europe (IPE). It should aid the recovery of investments that has been weak since the financial crisis. The core of the plan is the European Fund for Strategic Investments (EFSI), which contains a guarantee fund of 21 billion euros. For three years, this guarantee should trigger 315 billion euros of risk-bearing public and private investments. The focus of the fund is on infrastructure, innovation, and SME. The EFSI is accompanied by a tool to give practical support to investors (European Investment Advisory Hub, EIAH) and one to bring together instigators and investors (European Investment Projects Portal, EIPP). Finally, the plan commits the EC to a continuing pursuit of existing programmes, such as the Single Market, the Capital Markets Union, and the Better Regulation Agenda.

By November 2016, there were 385 approved projects. The total amount of investments triggered was 154 billion euros, implying that half of the target has been achieved. Of this amount, 32% went to SME, 20% to innovation, 22% to energy, and 26% to other infrastructure (such as transport, digital networks, environment, and social infrastructure). Belgium is relatively good taking advantage. Four infrastructure projects and seven SME financing agreements had been approved. Three of the infrastructure projects cover offshore windfarms (Rentel, Norther and Nobelwind), together comprising 600 million euros EFSI financing to trigger 3.2 billion euro of investments. The fourth is Ginkgo II, which is a Belgo-French equity fund for cleaning up polluted industrial premises. It got 30 million euros of EFSI funding, 6 million of which went to Belgium. The SME financing agreements totalled 58 million euros by June 2016, and were expected to generate 685 million euros of investments. About 2 100 Belgian SME benefit from the funds.

Though the IPE is on its way to reach the objective, some worries have been expressed too. The most important of these concern the concentration of projects in certain Member States and the ‘additionality’ of projects. The latter means that, because of their risk profile, the investments would not have been done without the EFSI guarantee. Other worries concern the lack of regulatory harmonisation among Member States, the eagerness of banks to participate, and the lack of visibility of projects. The EC has therefore proposed a series of amendments. The duration of the fund will be extended to 2020. It will be supplemented to reach 33.5 billion euros, extending the investment target to 503 billion. More emphasis will be given to the SME branch and climate issues. A more even geographical spread will be pursued, e.g. by making it easier to combine EFSI support with the European Structural and Investment Funds (ESI) and giving the EIAH more outreach at the local level. The additionality test will be refined. The revision may become effective by mid-2017.

More detail on the Investment Plan and its functioning is given in Annex C.

The major outcomes of the simulation are presented in Table 1, which gives the economic impact at 1, 3, 5, 10 and 20 years after the public-investment shock. The evolution of the most important variables presented in Table 1 is given as a deviation from the baseline except when otherwise specified.

Table 1 Economic impact of a 0.5 % of GDP shock to government investments in Belgium
Evolution in % deviation from baseline, except when mentioned otherwise

	1 year	3 years	5 years	10 years	20 years
GDP	0.24	0.48	0.82	1.63	2.77
Labour productivity	0.06	0.33	0.64	1.29	2.24
Employment rate (%-point deviation)	0.11	0.10	0.12	0.22	0.34
Private consumption	0.25	0.43	0.52	0.87	1.53
Private investment	0.02	0.13	0.30	0.76	1.51
GDP deflator	0.14	0.00	-0.21	-0.68	-1.32
Trade balance (% of GDP)	-0.40	-0.42	-0.32	-0.17	-0.05
Head tax (% of GDP)	0.07	0.24	0.33	0.32	0.13

Source: own calculations FPB, with a recalibrated version of QUEST III with endogenous growth.

When the government-investment rate in Belgium increases by 0.5 percentage points, GDP will have grown 2.77% above the baseline after 20 years. A significant part of the impact affects labour productivity which rises by 2.24% relative to the baseline while labour utilisation grows at a lower rate of 0.51%. This corresponds to 0.34 percentage points of the initial employment rate of 66.7%.

The increase in GDP is reflected in the different components of demand. Both private consumption and private investment increase, by 1.53% and 1.51% relative to the baseline over a 20-year span respectively. Note that the model predicts crowding in of private investment. However, both components grow at a lesser rate than GDP itself, reflecting the increasing relative importance of government investment in demand.

The increase in government investment by 0.5 percentage points leads to a progressive increase in government net capital stock which reaches 41% of GDP after 20 years and 43% of GDP after 40 years. These percentages are in line with what was observed at the beginning of the 2000s (see Graph 3).

The GDP deflator initially rises, reflecting increased demand pressures in the short run. In the medium to long run, the supply effects dominate and final goods price drops because of the rise in productivity. The trade balance, which is forced to be zero in the initial year, becomes slightly negative in the short to medium run. This is a consequence of increased demand for imports in the short run, and in the medium run because of a decrease in export prices, which follow the GDP deflator. In the long run, the trade balance converges to zero.

The head tax attains a value of 0.13% of GDP after 20 years. The value is positive, which means that the simulation does not support the idea of fully self-financed investment increase. In other words, there is no 'fiscal free lunch': the a priori possibility that the rise in GDP because of the shock is so high that it compensates for the increase in government expenditure, leading the debt-to-GDP ratio to drop without levying extra taxes. However, neither is it the case that government revenue has to be raised by the same amount as the investment expenditures, i.e. raising the head tax by 0.13% suffices to increase government investment by 0.5% in a budget neutral way. Of course, a head tax is a stylized, efficient form of taxation which is rarely present in real life. Different more realistic financing mechanisms, like a tax on labour or capital income or on consumption, are investigated below.

These results are in line or even more prudent than those obtained in other exercises of simulation, although this exercises are not tailored to a small open economy such as Belgium. Abiad et al. (2014) using the IMF's GIMF model simulated a permanent shock to public investments of 1% of GDP for an advanced economy. Since this is twice as high as the shock analysed here, and given their higher estimate of the output elasticity, their predictions for GDP are higher, both in the short term (2% vs. 0.24% rise in year 1) and in the long term (2.5% vs. 1.63% 10 years after the impulse). Melyn et al. (2016) using the EAGLE model of the ESCB simulate for Germany a temporary increase in public investments of 1% of GDP for 5 years, after which there is a gradual return to pre-reform levels. Their estimates on the short term are much higher (in the order of 1.2% dependent on the financing mode vs. 0.24%) while the values after 10 years are both around 1.6%. Moreover, they assumed an accommodating monetary policy during the first 2 years.

5.2. Alternative simulations

The basic simulation presented above constitutes a stylized exercise. To allow for more general conclusions, this section examines other specifications of the model.

In the first place, the head tax financing mechanism in QUEST III is replaced. As already mentioned, in the basic simulation, the debt-to-GDP ratio returns to its initial value after the shock. To ensure this, the rate of a debt-correcting head tax on households is fine-tuned. A head tax is efficient in the theoretical economic sense, meaning that people cannot strategically influence the amount of tax to be paid by changing their behaviour (labour supply, investment...). It is not often implemented in practice, though, presumably because of equity and political economy considerations. Therefore, some alternative financing modes, like taxes on production factors, are considered.

Secondly, to take into account the empirically established fact that not all types of public capital have an equally large effect on production, a budgetary neutral shift from less productive government investment towards infrastructure investment is simulated.

5.2.1. Alternative financing methods

This section looks at how the effects of raising government investment by 0.5% of GDP change when this increase is financed through more realistic channels. On the revenue side, compensatory taxes on labour income, on capital income and on consumption are examined. Additionally, a compensatory cut in government consumption is discussed. Finally, the last simulation removes the budget neutral constraint and allows for a debt financing shock. The tables below summarize the results for the short term (one year) and long term (twenty years), respectively, and compare with the basic simulation (first column).

Table 2 Effects after 1 year of raising government investments by 0.5% of GDP, different financing schedules
Evolution in % deviation from baseline, except when mentioned otherwise

	Head tax (basic sim.)	Labour income tax	Capital income tax	Consumption tax	Decrease government consumption	Debt financing
GDP	0.24	0.18	0.21	0.23	0.03	0.23
Labour productivity	0.06	0.09	0.07	0.07	0.05	0.07
Employment rate (% point deviation)	0.11	0.07	0.10	0.11	-0.01	0.11
Private consumption	0.25	0.18	0.38	0.35	0.60	0.32
Private investment	0.02	0.00	-0.26	0.01	-0.01	0.02
GDP deflator	0.14	0.17	0.15	0.16	0.04	0.16
Trade balance	-0.40	-0.40	-0.41	-0.44	-0.21	-0.43
Head tax (% of GDP)	0.07				-0.02	0.00
Respective implicit tax rate (percentage point increase)		0.08	0.08	0.07		

Source: own calculations FPB, with a recalibrated version of QUEST III with endogenous growth.

Both in the short and the long term, under real-life financing schedules, the policy intervention still raises GDP relative to the baseline, though less so than under the efficient tax scheme (0.24% after 1 year

and 2.77% after 20 years). In the short run, debt financing or increasing consumption taxes stay closer to the efficient head tax scenario, whereas a cut in government consumption has almost no positive effect²². In that case, there is no boost but only a shift in demand, leading to an even slightly negative effect on employment. Private consumption rises the most under the latter scenario. Indeed, since there is no increase in taxation, neither immediately nor in the future (as a consequence of rising debt), households can afford to spend more on consumption goods. The labour and capital income tax are more distortionary than the consumption tax: the former primarily due to a less pronounced rise in employment and private consumption, the latter due to a reduction in private investment.

However, it should be stressed that a rise in consumption taxes does not lead to higher wages in QUEST, which is at odds with the current Belgian mechanism of wage indexation. Hence, the distortionary cost of the consumption tax scenario will be higher under the current Belgian wage determination mechanism. Alternatively, this increase in indirect tax should have to be left out consideration by removing its impact on 'health' price index.

Table 3 Effects after 20 years of raising government investments by 0.5% of GDP, different financing schedules
Evolution in % deviation from baseline, except when mentioned otherwise

	Head tax (basic sim.)	Labour income tax	Capital income tax	Consump- tion tax	Decrease government consumption	Debt financing
GDP	2.77	1.69	1.89	2.69	2.43	2.69
Labour productivity	2.24	2.35	1.63	2.25	2.23	2.22
Employment rate (% point deviation)	0.34	-0.43	0.17	0.29	0.13	0.31
Private consumption	1.53	0.63	1.46	1.17	2.33	1.67
Private investment	1.51	0.81	-1.15	1.53	1.24	1.33
GDP deflator	-1.32	-0.74	-0.95	-1.31	-1.27	-1.25
Trade balance	-0.05	-0.05	0.10	0.05	-0.06	-0.11
Head tax (% of GDP)	0.13				-0.40	0.00
Respective implicit tax rate (percentage point increase)		1.40	2.49	0.73		

Source: own calculations FPB, with a recalibrated version of QUEST III with endogenous growth

The results in the long run mainly reproduce the short-run results, but with larger, cumulated effects. Supply effects now dominate demand effects, with the GDP deflator, positive at first, becoming negative due to the rise in productivity.

A noteworthy difference is that financing through a decrease of government consumption, which cancels beneficial effects on GDP in the short run, is less distortionary for private consumption and investment than either the labour or capital income tax scenario in the long run. This is likely to follow from the expiring of negative demand effects. While slightly less beneficial to GDP than the debt-financing and consumption tax scenarios, this financing mode has the most positive effect on long-term private

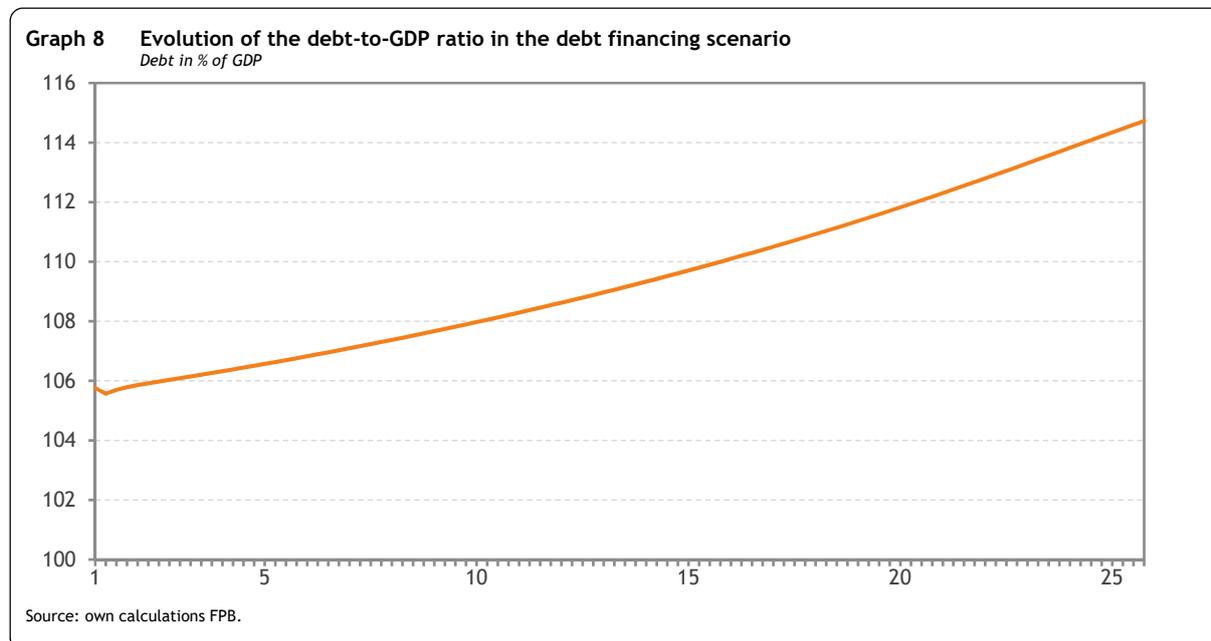
²² Note that in this government consumption scenario, budget neutrality is guaranteed in each period by decreasing government consumption by the same amount as the government investment without taking into account beneficial effects on GDP. This explains negative head taxes (transfer to households). This is stricter than the tax scenarios that do take these effects into account, though mainly in the long term. To impose budget neutrality in the long run in the government consumption scenario would entail deficit in the first years which would be less realistic and less prudent given the current situation of the Belgian public finances.

consumption. In part this is for the same reason as in the short run. An additional explanation is that the head tax under this scenario actually becomes negative, so that it becomes a head transfer to households, reflecting a shift to more productive government expenditures, while the debt-to-GDP ratio is assumed to remain constant in the long term.

Perhaps somewhat surprisingly, the increase in GDP is predicted to be smaller under this decrease of government consumption than when a higher consumption tax is levied. This result stems from the fact that (1) government consumption in the model is strongly biased towards domestically produced goods and services, so that a reduction decreases domestic demand considerably, and (2) the consumption tax pushes means away from private consumption into private investment, which leads to higher production. This increase in production does not, however, suffice to compensate for the initial shift away from consumption and into investment.²³

Also in the long run, a tax on labour is the most distortionary due to a considerable decrease in employment and a less pronounced rise in private consumption.

Debt financing has relatively more positive effects on long-term employment and private consumption than other financing modes, though this comes at the cost of somewhat lower private investment and more importantly, a debt-to-GDP ratio that is 6.36 percentage points higher than in the baseline after 20 years, as is shown in the graph below. So again, although public capital is productive in the QUEST III model, there is no 'free lunch' in the sense that additional public infrastructure investments would in the end pay for themselves, at least in a structural way.



²³ Maximizing utility or GDP does not yield the same result in neoclassical models based upon the Solow model. At lower levels of investment, consuming temporarily less to invest more will indeed raise steady state consumption (taken as an imperfect measure of utility) because production rises more than investment. But due to decreasing returns to scale, this is only true up to a certain level of investment (the so-called golden rule of capital investment). Above this level, production will still rise with additional investment, but not enough to compensate the loss in consumption due to extra savings. In these models, the highest level of GDP is attained when private consumption is 0 and all production is used to counteract depreciation.

Compared to Melyn et al. (2016), these results confirm their relative effects of different financing schedules in the short and long run, though, as before mentioned, their short-term predictions are much higher.

5.2.2. Different types of investment

As already described in section three, empirical studies aimed at estimating the output elasticity of public capital can often be distinguished according to the types of public capital they consider. Some studies take a narrow perspective and include only ‘core’ public capital, which consists of transport and communication infrastructure and infrastructure related to energy and other utilities. Others use a broader definition, adding e.g. public buildings, which is closer to the concept of government investment used in national accounts.

Bom and Ligthart (2014) find in their meta-regression that studies only concerned with core public capital (henceforth called infrastructure) report output elasticities that are on average 0.047 higher than studies where all public capital is involved. To account for this difference, the next simulation examines the outcome of a shock to infrastructure alone.

It is very important to note, however, that this simulation requires a recalibration of the QUEST model and therefore results are not comparable to those in Tables 2 and 3.

The financing scheme considered is a budget neutral shift of government investment from less productive (general) to more productive (infrastructure) projects leaving unchanged the total amount invested by government. In this option, government infrastructure investment increases from its 2014 value of 0.6% of GDP to 1.1% of GDP and other government investment decreases from its 2014 value of 1.8% of GDP to 1.3% of GDP. This shift allows the Belgian government infrastructure investment rate to catch up the Euro Area current ratio, still below the French and Dutch one.

To allow for two types of public capital, the default QUEST III specification was slightly rewritten. Using the same symbols as above, public capital KG was split into infrastructure $KG1$ and other public capital $KG2$, using the proportions observed for Belgium in 2014 in Eurostat’s COFOG data. This yielded $KG1 = 0.26101 KG$ and $KG2 = 0.73899 KG$. The corresponding output elasticities were derived from Bom and Ligthart (2014) and amount to $\alpha_{G1} = 0.16613$ and $\alpha_{G2} = 0.11913$. A calibration constant α_{G0} was included to ensure that in initial equilibrium:

$$KG^{\alpha_G} = \alpha_{G0} KG1^{\alpha_{G1}} KG2^{\alpha_{G2}}$$

The outcome of the simulation can be found in the table below. GDP is raised by more than 1% after 3 years and by more than 8% after 20 years. Labour productivity growth is particularly dynamic while the increase in labour utilisation takes more time to materialise. However, after 20 years, the employment rate increase is noticeable. In the long run, both private consumption and investment are boosted but the former much more than the latter.

Note also that under the assumption of a constant government debt ratio, this shift engenders a 'head transfer' (the tax is negative) towards households. Initially budget neutral, the shift leads to higher government revenues which are used in the model to lower the tax burden. In the real world, the budgetary margins can of course also be used to lower the public debt ratio or to have a combination of both.

Table 4 Effects after 20 years of raising government infrastructure investments by 0.5% of GDP
Evolution in % deviation from baseline, except when mentioned otherwise

	1 year	3 years	20 years
GDP	0.26	1.20	8.32
Labour productivity	0.21	1.47	7.64
Employment rate (% point deviation)	0.04	-0.18	0.42
Private consumption	2.14	4.14	8.00
Private investment	0.02	0.26	4.22
GDP deflator	0.23	-0.14	-4.07
Trade balance	-0.71	-1.22	-0.24
Head tax (% of GDP)	-0.09	-0.39	-1.29

Source: own calculations FPB, with a recalibrated version of QUEST III with endogenous growth.

6. Sensitivity analyses

In this section, the robustness of the previous analyses is checked. Like any DSGE model, QUEST III contains parameters that reflect fundamental assumptions about consumer choices, technological constraints, market structures, etc. In most cases, the values for these parameters are determined by results from empirical research. Often, however, there is considerable uncertainty about these estimated values, either due to the margins of error around intra-study estimates or due to wide ranges of estimates in the literature. The output elasticity of public capital is a case in point (see again Bom and Lighthart, 2014). To inform policy makers and citizens, it is hence crucial to give an idea of how conclusions and order of magnitude of the results would change if there are errors in the selected parameter values.

Of the hundreds of parameters and exogenous variables in the currently used version of QUEST III, four were chosen for a sensitivity analysis because they are conceptually relevant and important to the current study. These are the output elasticity of public capital, the elasticity of substitution between imports and domestic production, the share of liquidity constrained households and the asymmetry between the labour supply effects of raising after-tax income or lowering unemployment benefits.

The output elasticity of public capital α_G represents the percentage change in private sector productivity (in the final sector) following a 1% increase in public investments and plays a pivotal role in the simulations presented above. Its default value was set at 0.12 (rounded), as explained before. Reflecting the large range of estimates in the literature, the basic simulation was repeated for a low value of 0.06 and a high value of 0.18. The table below shows that the change in long-term GDP may be under-, resp. overestimated by a factor 1.5 if the real value is close to the higher, resp. lower end of the range of estimates.

Table 5 Effects after 20 years of raising government investments by 0.5% of GDP, sensitivity to the output elasticity
Evolution in % deviation from baseline, except when mentioned otherwise

	$\alpha_G = 0.06$	$\alpha_G = 0.12$	$\alpha_G = 0.18$
GDP	1.48	2.77	4.20
Labour productivity	1.07	2.24	3.56
Employment rate (percentage point deviation)	0.28	0.34	0.41
Private consumption	0.29	1.53	2.94
Private investment	0.86	1.51	2.20
GDP deflator	-0.68	-1.32	-2.01
Trade balance (% of GDP)	-0.01	-0.05	-0.11
Head tax (% of GDP)	0.34	0.13	-0.10

Source: own calculations FPB, with a recalibrated version of QUEST III with endogenous growth.

The elasticity of substitution of imports and domestic production σ is a measure of how easily households shift their consumption between domestically produced and imported goods as a consequence of a change in the relative prices of both goods. In the context of the simulation, it is important because increasing productivity leads to a decrease in prices of domestic goods. A higher elasticity thus leads to more private consumption of domestically produced goods (which could be considered as an extra demand channel). In the baseline, the parameter was set to three, which is an intermediate value in empirical studies. The effect of changing this parameter on GDP is more limited than was the case with α_G ,

but employment and private investment, and especially the deflator and private consumption are particularly sensitive to the value of this parameter.

Table 6 Effect after 20 years of raising government investments by 0.5% of GDP, sensitivity to the substitution elasticity of imports and domestic goods
Evolution in % deviation from baseline, except when mentioned otherwise

	$\sigma = 1$	$\sigma = 3$	$\sigma = 6$
GDP	2.67	2.77	2.77
Labour productivity	1.91	2.24	2.37
Employment rate (percentage point deviation)	0.50	0.34	0.26
Private consumption	-1.05	1.53	2.72
Private investment	1.02	1.51	1.64
GDP deflator	-2.67	-1.32	-0.71
Trade balance (% of GDP)	0.08	-0.05	-0.15
Head tax (% of GDP)	0.49	0.13	-0.03

Source: own calculations FPB, with a recalibrated version of QUEST III with endogenous growth

The proportion of liquidity constrained households SLC is important because as explained earlier, it determines the degree of anticipatory behaviour of households, thereby affecting how much difference can exist between debt financing and financing by a tax increase. The idea is that perfectly forward-looking households would treat an increase in government debt in just the same way as a postponed tax (Ricardian equivalence). Adding a share of households that, due to liquidity constraints, have to spend their entire current income, decreases forward-looking in the model and serves to bring model outcomes more in line with observed behaviour. The default value in QUEST for this parameter is 0.4. In the context of the current exercises, changing this proportion seems to have little effect, as is illustrated in table 7.

Table 7 Effect after 20 years of raising government investments by 0.5% of GDP, sensitivity to the share of liquidity-constrained households
Evolution in % deviation from baseline, except when mentioned otherwise

	$SLC = 0.2$	$SLC = 0.4$	$SLC = 0.6$
GDP	2.76	2.77	2.79
Labour productivity	2.24	2.24	2.25
Employment rate (percentage point deviation)	0.34	0.34	0.35
Private consumption	1.50	1.53	1.56
Private investment	1.49	1.51	1.53
GDP deflator	-1.32	-1.32	-1.33
Trade balance (% of GDP)	-0.04	-0.05	-0.06
Head tax (% of GDP)	0.14	0.13	0.12

Source: own calculations FPB, with a recalibrated version of QUEST III with endogenous growth

The final parameter, $CSEARCH$, is a monotonic, increasing function of the proportion between the labour supply effect of rising after-tax wages versus decreasing unemployment benefits. As explained, the currently used estimate of 2.33 (which corresponds to $CSEARCH = 0.64$) comes from Bassanini and Duval (2006), but following the range of estimates in the literature (e.g. Orlandi, 2012), a low value of 1.66 ($CSEARCH = 0.5$) and a high value of 4.17 ($CSEARCH = 0.8$) were simulated.

Table 8 Effect after 20 years of raising government investments by 0.5% of GDP, sensitivity to the parameter CSEARCH
Evolution in % deviation from baseline, except when mentioned otherwise

	CSEARCH = 0.5	CSEARCH = 0.64	CSEARCH = 0.8
GDP	3.04	2.77	2.61
Labour productivity	2.19	2.24	2.27
Employment rate (percentage point deviation)	0.55	0.34	0.22
Private consumption	1.81	1.53	1.36
Private investment	1.64	1.51	1.43
GDP deflator	-1.46	-1.32	-1.23
Trade balance (% of GDP)	-0.07	-0.05	-0.04
Head tax (% of GDP)	-0.02	0.13	0.22

Source: own calculations FPB, with a recalibrated version of QUEST III with endogenous growth

The lower the relative advantage of labour income tax reduction over unemployment benefits reduction in raising labour supply, the higher the effects of increasing the public investment rate on GDP, employment (self-evidently), private consumption and private investment. Since there is a lot of uncertainties about the estimation of these relative effects, the results here are presented mainly for illustrative purposes.

Conclusion

Can additional government investments in Belgium result in more economic growth? This is the central question around which this working paper revolves. Because there is a significant amount of uncertainty in the literature about what is exactly meant by the term, the concept was first clearly delineated. This allowed to determine the level of government investment in Belgium and its composition, situate this value in its historical context and make a comparison with our neighbouring countries. Thereupon, starting from the current situation, the effects of an increase in the investment intensity were modelled. Different scenarios, corresponding to alternative financing modes, were examined.

Concerning the delineation, this paper investigates investments by all organisations and institutions that belong to the institutional sector 'General government' as defined by the European System of National and Regional Accounts. The general government includes Central government, State government (Regions and Communities), Local government and Social security funds. This is the institutional sector covered by the fiscal monitoring of the EU. However, in Belgium as well as in other Member States, all entities owned or controlled by the government are not included in this sector. The term 'public investments' is therefore reserved for the broader group of government investments and investments by government-controlled entities.

Infrastructure investment receives particular attention given its importance for the rest of the economy. It contains on the one hand facilities for the provision of basic utilities like water, energy, communication and waste management, on the other hand transport infrastructure such as roads and railways, airports and seaports. Not all infrastructure is owned by the government and there are large differences in public-private sharing of infrastructure investment between countries.

General government investment has decreased in our country since 1970 from a 5% share of GDP to 2.4% in 2015, whereby the largest fall was realised in the eighties. Ever since, new investments were not always sufficient to compensate for the depreciation of the installed capital leading to a decrease in the net capital stock of general government. Since 1995, the government net capital stock of Belgium has decreased by almost 15 percentage points of GDP. Even when the broader concept of public investment taken in its largest interpretation, the public investment rate only amounts to 3.3% of GDP, still well below the rate reached in the seventies.

From an international perspective, the Belgian government investment rate is comparable to that of Germany (2.1% of GDP), just below the Euro Area average (2.7%) and far below those of France and the Netherlands (both around 3.5%).

The government investment rate in Belgium has not only decreased since the seventies but its composition has changed. The share of infrastructure investment in government investment has indeed decreased. In 2014, government infrastructure investment reached 0.6% of GDP in Belgium compared to almost 1% in the Euro Area, 1.3% in France and even 1.6% in the Netherlands.

Following the weak recovery after the financial and economic crisis, international organisations such as the European Commission and the IMF have often advised to increase the rate of government investment. In the short run, this would have the advantage that demand would rise and could stimulate the economy. Especially in the current economic climate, with negative output gaps, low inflation and low interest rates, possible negative side-effects in the form of increasing consumer prices and crowding out of private investment appear less likely. But, as opposed to government consumption, government investments also have an advantage in the long run, as has become apparent from empirical research: the productivity of the private sector is augmented by facilities like roads, telecommunication, power generation and distribution, so that private investment may even be crowded in. Hence, the increase in government investments may yield a double dividend.

Possibly, the extra growth caused by such an increase would compensate for the increase in government expenditures, preventing a rise in government debt. The measure would thus be self-financing. If, on the contrary, such a 'fiscal free lunch' does not materialise, the evaluation of the policy measure should of course take into account the possibly negative effects of distortionary taxes or rising public debt.

To examine the resultant effect of these interacting factors in Belgium, a simulation was carried out in which the government investment rate is structurally increased by 0.5% of GDP. To this end, the model QUEST III of the European Commission was used, adapted to the current situation in Belgium. Real GDP growth rises by 0.24 percentage points after one year and by 2.77 percentage points after twenty years. The largest share of this increase reflects higher labour productivity, though employment itself also slightly rises. Both private consumption and private investment growth increases by 1.5 percentage points within twenty years. The GDP deflator initially rises slightly because of increasing demand, but in the long run the productivity gain lowers inflation by 1.3 percentage points. Overall, a head tax of 0.13% of GDP is necessary to keep government finances stable at the current level. This excludes the possibility of a 'fiscal free lunch', because in that case the head tax would be zero or negative. But at the same time, the resulting economic growth ensures that only a quarter of the invested amount has to be covered by new government revenues.

Additional simulations were performed to check how these results would change when the measure would be financed in a more realistic way. In the long run, financing through debt or through a higher consumption tax turns out to have almost the same positive effect on GDP growth as under the efficient tax scheme, i.e. 2.69 percentage points. It should be noted, however, that the model does not fully include a wage indexing mechanism as the one that currently exists in Belgium. When the measure is financed by cutting other government expenses, GDP growth still rises by 2.43 percentage points within 20 years. A tax on labour or capital income detracts the most from the positive effects, limiting GDP growth to 1.69 and 1.89 percentage points, respectively. The former thereby mainly hampers employment and private consumption, while the latter causes private investments to fall. Private consumption is maximal under a cut in other government expenditures, because this scenario does not lead to additional taxes or government debt (i.e. postponed taxes). If no financing mechanism is devised, public debt will have increased by 6.5 percentage points after 20 years, rendering public finances unsustainable.

Starting from the observation that infrastructure investments have a larger effect in terms of GDP than other government investments, a shift in expenditures from the latter to the former has been simulated. Already after three years, this scenario results in a 1.2 percentage points increase in GDP growth.

Finally, sensitivity analyses were carried out for the most important parameters underlying this study. Not unexpectedly, the effect of the parameter representing the impact of a growth of public capital on output growth, the so-called output elasticity of public capital, is crucial for these conclusions. A more conservative estimate of it (50% lower) would, in the basic scenario, yield a GDP growth of only 1.48 instead of 2.77 percentage points after twenty years, while increasing the parameter's value by 50% would yield a growth of 4.2 percentage points. So, even though the value used in the basic simulation was chosen with care and is located in the middle of the interval of empirical estimates, caution is still warranted while interpreting these results.

Despite these overall positive results, this analysis leaves out some important topics. For instance, the optimal mix between investment in new infrastructure and maintenance of existing infrastructure has not been addressed. Similarly, the question of the government subsector (central, state, local or Social security funds) the best to invest is not analysed. Moreover, the outcome of single policy measure can be reinforced when combined with other structural reforms such as active labour market policies. Finally, the current analysis considers isolated investment effort while a more combined strategy at the EU level may generate important spillovers between Member States, especially for a small open country such as Belgium.

Annexes

Annex A: Government investment functional breakdown and investment by level of government

Table A1 Functional breakdown of government investment

Aggregation	COFOG codes
Infrastructure	04.3 Fuel and energy 04.4 Mining, manufacturing and construction 04.5 Transport 04.6 Communication 04.8 R&D Economic affairs 05.1 Waste management 05.2 Waste water management 06.3 Water supply
Hospitals and schools	07. Health 09. Education 01.4 Basic research
Public goods	01. General public services (except 01.4), 02. Defence 03. Public order and safety 05. Environment protection (except 05.1; 05.2) 06.4 Street lighting 04.1 General economic, commercial and labour affairs 04.2 Agriculture, forestry, fishing and hunting 04.7 Other industries 04.9 Economic affairs n.e.c.
Redistribution	06. Housing and community amenities (except 06.3; 06.4) 08. Recreation, culture and religion 10. Social protection.

Table A2 Belgian government investment by level of government and by type of investment (% of GDP), following the classification of Alegre et al., (2008)²⁴

General Government	2002	2004	2006	2008	2010	2012	2014
Total	2.1	2.1	2.0	2.1	2.3	2.5	2.4
Infrastructure	0.5	0.7	0.7	0.6	0.7	0.7	0.6
<i>Transport</i>	0.3	0.6	0.6	0.5	0.6	0.6	0.6
Hospitals and schools	0.6	0.7	0.6	0.7	0.8	0.9	0.9
Public goods	0.7	0.4	0.3	0.5	0.5	0.5	0.5
Redistribution	0.3	0.3	0.4	0.3	0.4	0.4	0.4
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Central Government	2002	2004	2006	2008	2010	2012	2014
Total	0.3	0.2	0.1	0.3	0.3	0.2	0.3
Infrastructure	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<i>Transport</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hospitals and schools	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Public goods	0.2	0.2	0.0	0.3	0.2	0.2	0.2
Redistribution	0.0	0.0	0.0	0.0	0.0	0.0	0.0
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Regions and Communities	2002	2004	2006	2008	2010	2012	2014
Total	1.1	1.1	1.0	1.0	1.3	1.2	1.3
Infrastructure	0.2	0.4	0.3	0.3	0.4	0.3	0.4
<i>Transport</i>	0.1	0.3	0.3	0.3	0.3	0.3	0.4
Hospitals and schools	0.5	0.5	0.5	0.6	0.7	0.8	0.8
Public goods	0.3	0.1	0.1	0.1	0.1	0.1	0.1
Redistribution	0.0	0.1	0.1	0.0	0.0	0.0	0.0
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Local Government	2002	2004	2006	2008	2010	2012	2014
Total	0.7	0.7	0.9	0.8	0.8	1.0	0.8
Infrastructure	0.3	0.3	0.3	0.3	0.3	0.3	0.2
<i>Transport</i>	0.2	0.3	0.3	0.2	0.2	0.3	0.2
Hospitals and schools	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Public goods	0.1	0.1	0.2	0.1	0.1	0.2	0.2
Redistribution	0.2	0.2	0.3	0.3	0.3	0.4	0.4

Source: Eurostat.

²⁴ In % of GDP, investment of Social Security funds is close to 0.

Annex B: Modelling the economic impact of infrastructure investment

This Annex gives a brief introduction into some other models that explicitly incorporate the impact of public capital. Most of these are general-equilibrium models. It includes those developed by the ECB and the IMF, but some author-made models are introduced too. These latter models are basic but hold certain features that are relevant for the analysis of infrastructure investments. One structural-econometric model will be introduced. It is the FPB's medium-term forecasting model HERMES. Though this latter model does not incorporate the supply-side impact of public investments, it is a detailed representation of the Belgian economy.

Reverting to the introduction of Section 4, general-equilibrium models seek to find a state where the economy is in equilibrium. Starting from microeconomic fundamentals, the forces of demand and supply are interacting and tend towards a clearing of all markets. The mechanisms at work are thus developed from theoretical constructions about the behaviour of economic agents. The interdependence among the economic sectors make the assembly of markets culminate into a system that allows for the analysis of relationships at the macroeconomic level. Because of this modelling approach, general-equilibrium models basically do not hold a detailed representation of the economy. Still – and as shown in this Annex – they can be quite sophisticated, taking account many relevant relationships of the economy into account.

The other class of models touched upon in this Annex is that of structural-econometric models. The mechanisms of these models are based on measured relationships between economic variables. They are thus developed from observed behaviour during the (recent) past. The relationships are often demand driven. The approach gives leeway to the development of models that hold a detailed representation of the economy. Structural-econometric models thus allow for accurate short- and mid-term predictions that build on observed economic behaviour.

NAWM

The New Area-Wide Model (NAWM) is a two-region DSGE model developed by the ECB.²⁵ It covers the Euro Area and the US, the latter considered as representative for the rest of the world. It was originally meant to analyse the ECB's monetary policy, but has been extended to the analysis of fiscal measures. In this context, Straub and Tchakarov (2007) attempted to compare the impact of public consumption *versus* public investment. They did so by introducing public capital into the production function.

There are two types of *firms*, one producing intermediate and the other producing final products. The intermediate products are tradable and produced under monopolistic competition, the final goods are not tradable and produced under perfect competition.²⁶ Public capital is introduced in the production of the former. There are also two types of *households*, which are either or not liquidity constrained. In

²⁵ For the specific features of the DSGE sub-class, see footnote 14 on page 22.

²⁶ The essential difference between monopolistic and perfect competition is that under the latter, goods are homogenous. There are no varieties, so producers cannot take advantage of the uniqueness of a product.

contrast to QUEST, the liquidity constraints are intertemporal, so the concerned households may substitute consumption over time by holding money balances. This way, though their lifetime consumption depends on labour income only, Ricardian equivalence may also play for them.

As in QUEST, fiscal *policy* builds on stabilising the debt-to-output rate and monetary policy follows the Taylor rule. Concerning the former, Straub and Tchakarov (2007) make mention of the imposition of an appropriate measure that corrects changes in fiscal policy. They are, however, not very specific about that measure, but seem to point towards a debt-controlling tax.

The demand-side impact of a public-spending increase is ambiguous. Consumption and investment of non-liquidity constrained households would fall because the corrective measure somewhat corrodes their intertemporal wealth. Consumption of liquidity-constrained households would increase since the rise in public spending would boost labour demand and real wages. This demand-side impact holds for both public consumption and investment. For the latter, however, a supply-side effect also plays, since they build up public capital serving as an input in the production of intermediate goods. The negative wealth effect would be partly offset through the increase in productivity.

GIMF

The Global Integrated Monetary and Fiscal Model (GIMF) is a multi-country DSGE model developed by the IMF. Freedman et al. (2009) and Kumhof et al. (2010) applied a five-region compilation, covering the US, emerging Asia, the Euro Area, Japan, and the rest of the world. The model allows for the analysis of fiscal instruments in interaction with monetary policy. It is built-up of many economic sectors. The structure among these sectors is defined from a ‘functional’ rather than an institutional perspective. To name a few, there are manufacturers, capital goods producers, consumption goods producers, import agents, trade unions, distributors, and retailers.

It is the sector of *distributors* where public capital comes in. They make their output from a composite of goods and the public capital stock. The goods are produced by domestic manufacturers, or come from import agents. The distributors’ product is sold to domestic and foreign consumption and investment goods producers. Throughout the stages of production there is a cascading of price rigidities that have a significant impact upon inflation and generates slow consumption dynamics (Kumhof et al., 2010). As in QUEST and NAWM, there are liquidity- and non-liquidity-constrained *households*. Where NAWM built in Ricardian equivalence in both types of households, GIMF does the opposite and builds in non-Ricardian behaviour in both. Liquidity-constrained households spend all their current income during the current period. Non-liquidity-constrained households have a finite time horizon, expecting to die at a certain but unknown moment in the future. This makes them attach more value to present consumption than to future taxes, which is at odds with Ricardian equivalence. Their government bond holdings therefore have a positive impact upon consumption, but crowd out physical capital and foreign asset holdings on the long run (Freedman et al., 2009).

Government carries out monetary and fiscal policy. It ensures a politically-chosen but non-explosive debt-to-GDP ratio by adjusting either tax rates or expenditures. The model allows for monetary accommodation of fiscal measures. Contrary to the Taylor rule, the nominal interest rate is kept fixed for a while in case inflation is accelerating. The thus reduced real interest rate incites producers to pick-up

investments. Elekdag and Muir (2014) explicitly built in time-to-build delays of public investments. This would say that only after some years of expenditures to build the infrastructure, it becomes part of the productive public capital stock.

In the framework of GIMF, government investments would have the following impact (see Freedman et al., 2009). On the demand side, the spending is received by the households as increased labour income and dividends, and consumed accordingly. The supply effect stems from the augmented public capital stock. This would make private production more efficient and increase potential output. Automatic stabilisers considerably offset the impact upon the budget deficit, which gives rise to further increases in consumption and investment. Because of the monetary accommodation, the increase in inflation would make real interest rates decline. This would also lead to a depreciation of the exchange rate, further stimulating aggregate demand.

Some other general-equilibrium models

A dynamic general equilibrium (DGE) model has been built by Rioja (1999, 2001, 2003ab), and applied to Latin-American development issues. Compared to the models discussed above, it only holds the basic economic relationships that are relevant for the analysis. Among these are some critical supply-side features such as the efficiency of public investments and the maintenance of public capital. The model is neoclassical in the sense that there is perfect competition and prices are not sticky. There are no monetary mechanisms. Machicado Salas (2007) argued that for the issues to be analysed, essential elements are not lost when compared to the application of more elaborated models. Machicado Salas (2007) developed a DSGE version of the model that would allow for including growth and the business cycle.

Rioja's model counts a large number of identical firms, who produce output from labour, capital and public infrastructure. There also is a large number of identical consumers, who are infinitely lived and spend their income during the current period. Government only carries out fiscal policy and balances its budget every period. Its only spending is on infrastructure, which is financed by raising a tax. So, contrary to the more sophisticated models, there are no distinction between intermediate and final output or other types of goods, no distinction between types of consumers, no public consumption, and no public debt.

The only instrument of fiscal policy is the tax rate that determines the amount of infrastructure. Raising public investment would thus have – in the words of Rioja (1999, 2001, 2003b) – a resource cost and a resource benefit.²⁷ The resource cost consists of the tax increase, which crowds out consumption and investment. The resource benefit consists of the replenishment of the public capital stock, raising productivity of labour and private capital. The impact upon output and private investment is thus ambiguous: hampered by resource cost but boosted by resource benefits. There should be an optimum level of infrastructure that depends on domestic conditions. One of these conditions is the efficiency of infrastructure in case the perceived – or effective – stock is smaller than the actual stock,

$$KG_t = \varphi KG_t^* \tag{A1}$$

²⁷ Machicado Salas (2007) speaks about a substitution and an income effect, respectively.

where KG^* is the actual public capital stock and $\varphi (\leq 1)$ the level of efficient use. The weaker the efficiency, the more difficult it would be for the resource benefits to match the resource costs. The notion of efficiency is elaborated differently in Rioja's respective analyses. It may refer to a certain degree of congestion (Rioja, 1999). It may refer to the quality of the infrastructure (Rioja, 2001). It may refer to the maintenance of existing infrastructure, on which the productivity of new infrastructure depends (Rioja, 2003ab).

A more elaborated DSGE model has been applied by Machicado et al. (2011). They built forth on a model of Chumacero et al. (2004), which they extended with public capital. There is one type of household. It is infinitely lived and can trade foreign assets. There are five industries, respectively producing agricultural goods, minerals, hydrocarbons, import substitutes and non-tradables. Each industry is endowed with the same public capital, which is not fully productive because of efficiency issues. Government only carries out fiscal policy. The modelling of this policy is relatively close to reality. Besides public investments, there are public consumption and social benefits. Tax rates are linear, but cover consumption taxes and excise and import duties. The budget should balance in each period. Machicado et al. (2011) do, however, not make clear how this takes place, since all tax rates and expenditures seem to be fixed. For reasons of simplicity, there is no labour and labour income. The model is applied to analyse the economic impact of fiscal and structural measures in one specific country (Bolivia). Because of their productive impact, public investments would have a stronger impact than public consumption. Concerning structural policy, a positive impact of the improvement of TFP and the effectiveness parameter was shown.

The merit of these basic approaches is the transparency and comprehensibility of the mechanisms at work. Still, a simulation's outcome may be biased since essential characteristics of the real world – such as imperfect competition, Ricardian equivalence, and government debt – are not modelled. Instead, these specific studies pay attention to the efficient employment of public capital and the issue of new construction versus maintenance.

HERMES

The FPB's structural-econometric model HERMES has been developed for making medium-term outlooks for the Belgian economy. It is a detailed system of economic interactions and is based on time series analysis. The model is demand driven, although there are also certain supply-driven elements. With respect to the other models discussed here, it is no general-equilibrium model and there is no public capital in the production functions. By contrast, HERMES holds an elaborated modelling of the Belgian tax and benefit system, interindustry linkages, the allocation of consumption, labour-market segmentation, and energy and environmental issues. It thus represents the institutional system of the country. The model is extensively introduced by Bassilière et al. (2013).

The corporate sector consists of 15 industries. Each produces output from labour, capital, energy, and other intermediate inputs. Households prefer to smooth lifetime consumption, which is a positive function of human wealth (discounted current and future income and current financial wealth). However, consumption is in the short term constrained by current disposable income. Government carries out monetary and fiscal policy. The taxes represent the Belgian fiscal system and depend on their respective

tax bases. There is no convergence to certain deficit and/or debt targets. Instead, the model diagnoses the deviation from such targets, inciting government to correct the imbalance.

In concordance with ESA2010, there are six types of capital goods: Cultivated assets, Transport equipment, Other equipment, Dwellings, Other buildings and structures, and Intangible assets. As argued earlier, network infrastructure is best characterised as belonging to the Other buildings and structures. Public investments are modelled as a subsidy to the corporate sector, which produces the actual investment goods. For infrastructure, it is the construction industry that gets most of the impulse. Simulations made by Bossier and Vanhorebeek (2000), Bossier et al. (2004) and Bassilière et al. (2013) have shown that there should be a positive impact upon GDP and employment. Since the impact is inflationary, it weakens in the medium term, despite the endogenous wage evolution that – following the wage indexation mechanism – is partly determined by the price evolution. Part of the impact leaks away via imports. The impact upon the government balance is negative, though alleviating because of the strengthened GDP growth. Bossier et al. (2004) noted that there may also be some supply-side impact since the investments make the infrastructure more attractive for its users.

Synthesis

The basic characteristics of the models discussed in this paper are summarised in Table B, though only insofar the models differ from each other. There are also common elements. In each model that includes the supply impact, the basic channel is that the public-capital stock serves to increase productivity of labour and private capital, and thus has a more pronounced impact upon output than a public-consumption shock would have. Furthermore, in each of these models the output elasticity of public capital is constant and does not depend on other factors. Finally, in each model except Rioja's, automatic stabilisers are at work via the tax system.

The three international institutions' DSGE models are comprehensive and suited for the analysis of the economic impact of government investments and other structural policy measures. The models of Rioja (1999, 2001, 2003ab), Machicado Salas (2007) and Machicado et al. (2011) are basic, but include the useful notions of the efficiency of public investments and the trade-off between network maintenance and extension. HERMES, finally, allows for making precise predictions for the Belgian economy, but holds no supply-side transmission channels.

Table B1 Synopsis of models that include the economic transmission of public capital

	QUEST III	NAWM	GIMF	Rioja's model	Machicado <i>et al.</i>	HERMES
Basic characteristics						
Type of model	DSGE	DSGE	DSGE	DGE	DSGE	Macroeconometric
Detail	Moderate (basic elements of the real world)	Moderate (basic elements of real world)	Much (detailed step-by-step production chain)	Very little	Little	Much (representing the national economy)
Calibration	Belgium & EA & RoW	Euro Area & USA	Five country groups	Latin-American countries	Bolivia	Belgium
Modelling of public capital						
Producer types	Three	Two	Many	One	Five industries	Fifteen industries
Production function of	Final goods	Intermediate goods	'Distributors'	That one	All	None
Inefficient usage	No	No	No	Yes	Yes	No
Endogenous	Yes	Yes	Yes	Allowance for	No	No
Modelling of government						
Funding of public investment	ST: debt-financed LT: budget neutral	Not explicitly stated for these models Presumably ST debt & LT neutral		Year-on-year budget neutral	Year-on-year budget neutral	Year-on-year debt-financed
Budget adjustment	Debt-controlling lump-sum tax	Adjustment of existing taxes (lump-sum?)	Adjustment of existing taxes and/or spending	Lump-sum tax	Unclear (all elements of budget seem exogenous)	Not automatically
Monetary policy	Taylor rule at EA	Taylor rule	Interest-rate smoothing & monetary accommodation	No	No	Exogenous interest rate
Modelling of households						
Household types	Liquidity and non-liquidity constrained	Liquidity and non-liquidity constrained	Liquidity and non-liquidity constrained	One (liquidity constrained)	One	One
Ricardian equivalence	Non-liquidity constrained	Both household types	Non-Ricardian features in both	n/a	n/a	No

Annex C: The Investment Plan for Europe²⁸

Short after the new European Commission (EC) took office in 2014, it launched the ambitious Investment Plan for Europe as one of its priorities. The core of this plan was the establishment of a guarantee fund to trigger 315 billion euros of public and private investments. The Investment Plan consists of three pillars that – together – would strengthen the risk bearing capacities of the Member States' economies: (1) mobilising finance for investment, (2) making finance reach the real economy, and (3) improving the investment environment.

- The third pillar – to start with – seeks to support the improvement of the general investment climate. It involves a continuing pursuit of existing European programmes, such as the Single Market (e.g. Energy Union, Digital Single Market, Single Market for Services), the Capital Markets Union, and the Better Regulation Agenda. At Member State level, it involves the pursuit of growth-friendly fiscal consolidation, the implementation of structural reforms and tackling specific investment barriers.
- The second pillar comprises the establishment of the European Investment Advisory Hub (EIAH) and the European Investment Projects Portal (EIPP). The EIAH gives practical support to investors. The hub is a single access point giving a wide range of advice on prospecting, developing and accomplishing investment projects, access to finance, and the use of financial instruments. The EIPP allows instigators to share their projects and ideas with potential investors. This may improve transparency.
- The first pillar is the European Fund for Strategic Investments (EFSI), and is considered the core of the Investment Plan. The fund is established through Regulation 2015/1017 (together with the EIAH and EIPP), which was signed on the 4th of July 2015. For three years from that day, it would back risk-bearing investments by a guarantee fund lodged at the European Investment Bank (EIB). The fund would initially hold 21 billion euros, which would be able to trigger investments up to 315 billion euros by a two-step multiplier effect. The first step is that it increases the financing capacity of the EIB by three times the size of the fund (63 billion euros). The second is that the EIB on average contributes 20% of the financing needs of investment projects, thus leveraging five times its financing capacity (315 billion euros). Each project that might be eligible for EFSI funding is evaluated by the Investment Committee, which consists of independent experts. It employs a series of criteria, one of which is 'additionality'. This would say that, because of its risk profile, the investment would not have been done without the EFSI guarantee. Other criteria are economic viability, raising sufficient private capital, and the contribution to EU policy priorities. Concerning the latter, two branches of investment are considered eligible. The one covers specific projects on infrastructure and innovation, the other financing agreements for SME and midcaps. There is no project- or fund-allocation quota per Member State. Thanks to the guarantee fund, the EIB may take more risk than usual. It also widened its spectrum of instruments with e.g. subordinated debt and equity participation.

By December 2016, there were 420 approved projects, 176 of which were on the infrastructure and innovation, and 244 on the SME branch (the latter benefitting 388,000 companies). EIB financing totalled 30.5 billion euros, and triggered investment up to 164 billion euros. This implies that more than half of

²⁸ Sources: EC communication COM(2014)903 on an Investment Plan for Europe; fact sheets on the Investment Plan; seminars of 15 and 21 June and 21 November 2016, the first organised by Confrontations Europe and the other two by the Representative of the EC in Belgium; press releases of 6 and 23 December 2016.

the target has been achieved, with a multiplier being somewhat higher than set (5.4). The sectoral distribution of the investments was as follows: 32% on SME, 20% on innovation, 22% on energy, and 26% on other infrastructure (such as transport, digital networks, environment, and social infrastructure).

Belgium is relatively good taking advantage of the Investment Plan. By May 2016, it ranked 6th in number of projects. By November, four infrastructure projects and seven SME financing agreements had been approved, and most of them were already signed. Three of the infrastructure projects cover off-shore windfarms (Rentel, Norther and Nobelwind), together comprising 600 million euros EFSI financing to trigger 3.2 billion euro of investments (multiplier of 5.3). The fourth is Ginkgo II, which is a Belgo-French equity fund for cleaning up polluted industrial premises. It got 30 million euros of EFSI funding, 6 million of which went to Belgium. The SME financing agreements were closed with commercial banks (such as Belfius and ING) and regional participation funds (such as Sowalfin and PMV). By June 2016, the funds' risk-sharing capacity already totalled 58 million euros, and were expected to generate 685 million euros of investments. About 2,100 Belgian SME then benefitted from the funds. The EIB noted that running a project in Belgium is somewhat complicated because of the country's state-structure. It makes them refer to more points of contact than necessary.

During 2016, three evaluations of the Investment Plan have been made: one by the EC, one by the EIB and one by Ernst & Young. In general, the first year has been satisfactory and the Plan seems on its way to reach the objective set. However, there also are some worries. Though the projects cover all Member States, there is a tendency of concentration in certain of them. Especially France and Italy benefitted more than proportional to their economic size. By May 2016, they had together got 29% of the approved projects (71 out of 249). As noted, Belgium had done well as well, and three other large economies were in between (the UK, Germany, and Spain). All other Member States had achieved less than ten approved projects. Further worries were about the additionality, the lack of regulatory harmonisation among Member States, the eagerness of banks to participate, and the lack of visibility of projects. The EC has therefore launched a new Investment Package in September 2016, holding refinements to the Investment Plan through a proposal to amend Regulation 2015/1017.

Foremost is the extension in time and funds. Projects may be submitted until the end of 2020 instead of mid-2018. The EFSI may be supplemented to reach 33.5 billion euros, extending the investment target to 503 billion. More emphasis may be given to the SME branch and climate issues. Concerning the former, the proportion of funds available for SME will rise. Concerning the latter, 40% of the funds must be used to combat global warming. To act upon the geographical spread, it should become easier to combine EFSI support with the European Structural and Investment Funds (ESI). The EIAH will get more outreach at the local level to exploit local knowledge. It will also give more pro-active support on the establishment of investment platforms. In an investment platform, similar projects – even if they are from different countries – are promoted together to get combined financing. The additionality test will be refined. Projects 'shall typically have features such as subordination, participation in risk-sharing, cross-border characteristics, exposure to specific risks or other identifiable aspects'. The package was approved by the European Council in December 2016. It is expected that the European Parliament will follow by March 2017, making the package to be implemented by May or June.

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